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REPORT

Learning from the past Looking to the future

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Learning from the past Looking to the future

**Proceedings from the
Northern Silviculture Committee's 1988 Winter Workshop
February 2 & 3, 1988
Prince George, B.C.**

Edited by
Brian A. Scrivener
and
J. Andrew MacKinnon

February, 1989

Northern Silviculture Committee in cooperation with

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Canada



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Foreword

The idea to hold a Forest Resource Development Agreement (FRDA)-sponsored Northern Silviculture Committee (NSC) Winter Workshop was first proposed by Lorne Bedford, Project Leader for FRDA 1.15. Lorne suggested that a contractor be hired to contact potential speakers and assist them with preparations for their presentations. With the approval of the NSC executive, the project went ahead.

The contractor hired, John Bartlett, spent several months lining up the 30 speakers represented here. The speakers submitted their papers, which were subsequently edited for length. Technical material in the presentations has been retained. All references to other literature have been compiled and placed in the "References" section at the end of these Proceedings.

The workshop attracted in excess of 360 participants. In addition to the technical sessions, there was a herbicide seminar immediately before the workshop, more than 20 commercial booths displaying their products throughout the workshop, and two well-attended poster sessions in the evenings. The speakers, the organizing committee (myself, Marty Osberg and Dave Coopersmith), other NSC members (Lorne Bedford, Shelley Burns, Heather Dawson, Maureen Schulting and Al Todd), moderators for the different sessions (some of the above, as well as Kathy Campbell, Roberta Parish, Jim Sherb, Dave Wilford and Bill Williams), and the staff at the Inn of the North (particularly Reenee Partel) worked together to ensure that the meetings ran smoothly. The text for the Proceedings was word-processed by Brian Scrivener and typeset by Beth Collins. Jacqueline Verkley prepared many of the figures. All of the above deserve great credit for an excellent workshop and Proceedings.

Finally, thanks are due to FRDA 1.15, which funded the contractor who contacted the speakers, and which subsequently funded preparation and production of these Proceedings. This is the second joint NSC-FRDA production in two years (the first being the Second Edition of "A Guide to the Use of Mechanical Site Preparation Equipment in North Central British Columbia"); these co-operative ventures assist both the NSC and FRDA in achieving their goals.

Andy MacKinnon
B.C. Ministry of Forests
Research Branch
Victoria, B.C.

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Introduction

by

Andy MacKinnon, Chairman
Northern Silviculture Committee

The goal of the Northern Silviculture Committee is to "promote co-operation, understanding and improvement in the application of silvicultural practices at the field level." While the NSC performs this function in a number of ways, perhaps its primary role has been to transfer information between researchers and the general body of silviculturists in northern Interior British Columbia. Results from operational trials and research projects are presented to the NSC membership at Section meetings, our Annual General Meeting and at special Winter Workshops (such as this one and the Interior Spruce Symposium held several years ago).

The NSC is a vital organization at present. The fact that we can consistently fill our AGM's and workshops suggests that silviculturists find these meetings to be amenable to effective information transfer. If this in turn leads to an improvement in silvicultural practices, then the NSC has fulfilled its mandate; that part, of course, is up to you.

There is a lot of research, and a lot of silvicultural activity in general, taking place in our part of the world these days. This is due in large part to funding provided by the Forest Resource Development Agreement (FRDA) for backlog rehabilitation. It goes without saying that members of the NSC agree with the objectives of our current Federal-Provincial FRDA agreement, and we must join in lobbying for another agreement to replace this one, which expires in March 1990. While the NSC will consider a motion of support at our AGM this summer, nothing can replace individual contact between our members, their MLA's and their MP's.

In general, the "clearly targetted user group" of much of the Northern Interior Technical Advisory Committee's FRDA-sponsored research is the NSC membership. Because of this, FRDA not only co-sponsored this workshop but has also underwritten the cost of printing the Second Edition of the "Guide to the Use of Mechanical Site Preparation Equipment in North-Central British Columbia."

These co-operative efforts between the NSC and FRDA benefit both parties. Many NSC members work directly or indirectly with FRDA funds as we attempt to bring NSR lands back into coniferous production. On the other hand, the NSC can assist FRDA in its extension and development activities. We look forward to working closely with FRDA over the remaining two and a half years of this agreement, and into the next.

This conference is designed to look into various aspects of backlog rehabilitation, from site preparation (sessions on Prescribed Fire and Mechanical Site Preparation) through seedling production and planting (Nurseries, Planting) to stand tending (Vegetation Management) and pest and wildlife interactions (Other Concerns). Presentations range from the theoretical to the practical, from large-scale operational projects to intensive research trials. I trust that our glimpses of the past these next two days will help us "look to the future," and I hope that we'll all bring home useful information that will benefit us, and our seedlings as well.

A Look Back at the Beginnings of the Reforestation Program in British Columbia

by
Ray Williston
Gibsons, B.C.

The development of a program for reforestation does not depend only upon the legitimate needs of forest management; it is also influenced by attitudes, disasters, political considerations, available finance and even the personal bias of executive managers. And sooner or later public concerns about future forest productivity will focus attention on the need for action. To understand what has taken place, one must go back to the beginning of government administration and look at the public perception of the tree-covered land which made up most of this province when trees were a hindrance to development, rather than a secure source of revenue. Fires helped to clear land for more productive uses, so they were never taken seriously and only fought when other assets were threatened. Gradually, as governments required more revenues they looked to standing trees to provide some of the needed dollars. However, this was not before land had already been sold where no value was attached to the timber and no right had been imposed to collect future royalties when trees were harvested.

A first change in policy allowed for future royalty collection at the time of harvest, and in 1906 the sale of timber land was no longer permitted. A problem remained as to what constituted timber land, and this was not resolved for many years. In place of land sales, licences to cut standing timber were issued only to those companies with sawmills or pulpmills — operating or not. An annual acreage rental was paid and royalties collected at the time of harvest. There was no mechanism to enforce performance. To stimulate greater revenues, it became policy to sell timber licences with no obligation to perform. The non-performers paid a higher annual rental fee than the performers, but there was a common royalty on harvest. Such licences could be sold or traded, and their acquisition became very popular. For the most part, tenures were issued in 1.6 km² blocks, and soon they occupied nearly every river mouth on the coast, as well as any other accessible timbered area. These common yellow squares appeared on all land maps for years. Since more than 15 000 licences had been issued in a very short time, there was concern that the province could be running out of trees to cut just at the time people were beginning to realize that timber was a valuable resource and that British Columbia had more than any province in Canada. Responsibility had to be assumed to protect the timber granted under lease, or future revenues would be lost. There was no proper organization to fight fire, to police the industry, or to collect revenue.

To resolve the problems, a Royal Commission was asked to look into the afforestation of barren areas, but reforestation was never mentioned. The Commission recommended that a Forest Service be formed within the Department of Lands to administer the timber resources. This was done in 1912; for a short time H.R. MacMillan was Chief Forester. Priority would be given to the prevention of fire, the control of waste and the limitation of cut to mature trees. It was accepted that natural regeneration would take place and that in the future 3-12% of cutover lands might have to be planted along with barren areas.

By 1915 the number of Forest Service personnel had increased from 110 to 378. There were even 44 in Prince George, a few more than this in the Victoria headquarters, and twice as many in Vancouver. Fighting forest fires was the prime activity. Since most forest fires were started by people, pocket whetstones bearing the message "Prevent Forest Fires" were handed out in great numbers.

In 1920, a severe beetle infestation was reported in the Merritt and Penticton areas, but no action was taken. In 1921, a sulphite mill was slated for Prince George. The mill required 85% spruce, and 75% of the trees had to be 23 cm top diameter and larger. This required both timber surveys and growth studies to be undertaken in the surrounding area.

The first recorded study on natural regeneration related seed distribution from a Douglas-fir tree 53 m high. As a matter of interest, seed went 160 m downwind, 99 m upwind and 122 m at the right angle. In this same active year aircraft were tested for fire patrols two days a week from Point Grey to Thurston Bay. The conclusion was that the machines had some potential. A portable pump was perfected at this time. The next year the use of wireless telephones was extensive. The number of calls and the number of words were all recorded.

In 1923 there was a British Empire Forestry Conference in Canada, which resulted in the first evidence of internal politics in the Forest Service's annual report. Recommendations of the Conference having to do with silviculture were quoted in full. It was recommended that attention be given to leaving seed trees, to logging small compartments permitting seed throw, and to undertaking research on the principal species to be selected for stocking timber lands.

In 1924 a soil and land classification division was established in the Forest Service because there was worry about the alienation of timber lands. The next year, natural reproductive studies were undertaken on hemlock and Douglas-fir cutovers. In the same year the first plantings were reported: 7500 deciduous trees in the vicinity of Oyster River on Vancouver Island. They were alder, black cottonwood, ash, Manitoba maple and caragana. The purpose of the planting was to serve as firebreaks on both dry and wet sites. A site was also selected for the Aleza Lake Experimental Station. The land between Quesnel and Prince George was classified for forestry and agriculture. This later formed part of the special sale area and caused problems with earned cutting rights when working circles were established.

In 1927 the newly created Research Division leased several Shelbourne Street lots from the Municipality of Saanich. The ground was prepared for 30 seedbeds each 1.2 by 3.7 m. The next year these were planted with Douglas-fir and Sitka spruce. Information was gathered for a permanent forest nursery on the coast, while a smaller nursery plot was established at Aleza Lake. Forest Rangers were brought to Aleza Lake to observe experimental work in forest management.

In 1929 a permanent nursery site was selected at Green Timbers: 251 ha of federal lands were reserved and two ha were cleared to accept seedlings transferred in 1930 from Victoria. The Cowichan Experimental Farm was established to concentrate on Douglas-fir. Cones selected for seed were identified by source for the first time.

Experimental planting with stock from Victoria, and later from Green Timbers, was carried out at the Forestry Station and in the Campbell River Experimental Forest. By 1932 sufficient stock had been accumulated to plant 221 ha on West Thurlow Island. About half of this area was classed as experimental and the other half as a production forest.

In 1935 the Shelbourne Nursery was closed and the lease allowed to lapse. Nursery techniques had been developed and almost one million seedlings produced in 5½ years. It became Forest Service policy to encourage tree planting by the public at large. Forty-four different parties received almost 50 000 trees during the year. This did not include 16 ha planted by Elk River Timber — one of the first sites planted by industry. It should be remembered that this was during the Depression when money for planting was scarce.

Problems were experienced with getting rid of seedlings. Those left too long in the nursery and considered oversize had to be destroyed. As a result, a survey of areas for planting was deemed necessary, and 13 770 ha were chosen for examination. The next year, 6075 ha in the Sayward Forest near Campbell River were chosen for a concentrated reforestation effort, and in 1936 the first 43 ha were planted.

The Young Men's Forestry Training Plan, funded by the federal government as a Depression measure, helped with the provincial forestry program at all levels, since staff had been reduced to 193 persons. The number of young men employed continued to increase. Much of their time was spent in developing recreational facilities on forest lands. A first mention was made of multiple use of forest areas.

Many low cost innovations were introduced to improve nursery techniques. These included high-pressure torches to control early weeds, an oscillating root pruning blade which operated 10 cm below the surface and another angled blade used for lifting seedlings.

In 1938 150 000 seedlings were planted on 65 ha. In that same year a disastrous fire at Campbell River destroyed 30 375 ha — one-third of the total lost in the whole Vancouver District. In response, government policy determined that in future 4050 ha would be planted each year; 6 ft. by 6 ft. planting at 2471 seedlings per ha was recommended treatment. To meet the planting goal by 1942, Green Timbers nursery would target a capacity of six million, with four million to come from the new Quinsam nursery at Campbell River. An expanded program of seed collection was also introduced. The new activity resulted in a major Forest Service reorganization. An Economics Division was made responsible for reforestation. Production planting as opposed to experimental work would assume greater importance on Crown land.

For the first time, forest companies, communities, and private land owners — including farm wood lots — could all be provided with seedlings and were encouraged to plant. In 1941 over eight million seedlings were planted on more than 4050 ha, and close to that rate continued for four years. This was made possible because Alternate Service Workers (conscientious objectors) were made available to the Forest Service for all types of seed collection, nursery, access and site preparation work, including snag falling.

Regeneration surveys during this period revealed some 39 690 ha in the Cowichan Valley required reforestation. To meet this demand a nursery was purchased at Duncan with a planned annual capacity of six million seedlings. It actually came into production in 1947.

With the end of World War II, the labour pool provided by the Alternates disappeared, and only 567 ha were planted in 1945. Nurseries at Green Timbers and Campbell River could not move their stock. Since there was no manpower to plant new seedbeds, the seedlings were retained in their beds.

Meanwhile, early in 1944 the late Honourable Gordon McG. Sloan had been appointed to investigate the forest resources of British Columbia. His report, presented at the end of 1945, recommended that approximately 400 000 ha of not satisfactorily restocked land on the coast should be planted within 25 years. He stressed that productive forest land should not be allowed to remain idle, and he advocated examination of the cutover lands of private holdings to determine the extent of reforestation required. He was particularly interested in the present and former E & N Railway lands on Vancouver Island. His suggestion of compulsory reforestation of such land eventually led to that requirement under Section 152 of the Forest Act.

In 1946, Forest Service Economics Division staff who were working on reforestation were formed into the Reforestation Division, responsible for the production of nursery stock and the planting of Crown land.

Even though the prime impact of the Sloan Report was to introduce new forest management techniques and organizational procedures, major attention had also to be paid to the need to reforest cutover land and plant areas that were not stocked satisfactorily. However, the next decade would reflect the Forest Service's stated opinion and focus: that the introduction of Forest Management Licences was the most important act taken since the organization of the Forest Service 35 years before.

Because of the postwar shortage of labour, school students were employed in the nurseries during their off-hours. Soldiers were tried since there was now little for them to do, but they proved to be very unproductive and disinterested. With labour and money short, mechanical devices were introduced where possible. Soil spreaders and compost mixers were gradually modified until they worked efficiently. A three-burner torch destroyed early weeds in one pass over the seedbeds, and electric clippers proved most productive.

In 1947 much of the three-year hold-over stock was planted but with poor survival, resulting in a policy that this would not be repeated in the future. Fertility of the nursery beds had also suffered. Actual planting reached only about half that accomplished in the war years.

In 1943 when the Duncan nursery land was purchased, the targetted production for nurseries following the war was to be 20 million seedlings per year. However, the reality of operating conditions in 1948 determined that the coast nurseries could target for only 10 million, the highest average annual plantings yet to be achieved. To dampen the impact of this decision an experimental nursery was opened at Elko — a yellow pine region in the East Kootenays where 24 300 ha had not been restocked. The first experimental planting on the west coast of Vancouver Island was done with Douglas-fir at Tahsis.

As logging moved higher up the mountains, attention was gradually being directed towards the production of hemlock. To secure sufficient seed it was decided that green cones must be harvested and a drying shed provided.

With the establishment of Forest Management Licences in 1948, private industry took increasing responsibility for planting. Much of this was done on large contiguous clearcuts on bottom lands which had once been typical of railroad logging. An attempt was made to contract snag falling, but few people could estimate their costs in advance.

Even the new goal of planting 10 million seedlings each year proved difficult to achieve. Weather, grubs, soil fertility and new types of weeds combined to have a detrimental effect. There were few productive years without new problems. The development of efficient nurseries was proving to be a major learning process with little helpful information from elsewhere. The unique and widely varying conditions found in British Columbia had to be mastered on a site-by-site basis.

With the initial production of yellow pine, Douglas-fir and spruce at Elko came confrontation with ranchers who did not want trees to interfere with cattle grazing on the bottom lands of the valley. A new nursery site was chosen at Perry Creek because Elko did not prove suitable. However, the opposition of the ranchers intensified because machine planting, then under experiment, worked best on the flat lowlands. With adverse local reaction and poor site conditions for planting, Perry Creek did not prove productive for growing stock suitable for other areas and was finally turned over to the Regional District for park use in 1969.

Early in the 1950s, all Douglas-fir sites planted since 1930 were examined. These were found to be dominated by brush and had to be cleared to encourage growth. This work was started in 1952. Improvement work, such as pruning on areas of natural reproduction, was also undertaken at this time.

Seed collection remained a continuing problem. Nature seldom cooperated to provide desired quantities of seed from the right places. One thing was certain: when the forest did produce the seeds they had to be collected in as large quantities as possible, in any way feasible. Refrigeration then became necessary to preserve the stored seed. The higher up the mountain the loggers cut, the more difficult it became to secure seed. At times there was not even enough to plant the available seedbeds.

Much time was still spent trying to grow hemlock successfully in nurseries. Different soil cover, shading, planting with other species and special seed treatment were all tried with varying results.

In 1953, planting by companies and other private bodies exceeded that of the Forest Service for the first time. Even so, just over half of the total planting goal for the year was reached. From this time on, annual survival was checked; this varied between 58-89% on the coast and from 18-52% in the interior.

Increasing demands to fund activities not directly related to nursery production reduced the amount of money available for nurseries. For example, the regeneration surveys now being undertaken cost 42¢ per ha on the coast and 35¢ in the interior. Roads in coastal plantations had been built and maintained only to provide restricted, rough truck access. Public interest in forest recreation forced expensive upgrading to permit cars to be driven safely through plantation areas, especially where lakes or rivers could be reached or where good hunting was possible.

Sloan's second Royal Commission report was completed in 1956 and published the next year. The implementation of the report quickly educated a new Minister in forestry and in dealing with forest companies. For a time before his untimely death, Sloan was named as a forest advisor and helped with the interpretation of his report.

Sloan was critical in his observations about the reforestation program, and he disagreed with some Forest Service officers. Dr. Orchard, the Deputy Minister, contended that it was uneconomic to produce and plant more than ten million seedlings each year. This number, he believed, would meet all current need and handle the backlog which had developed. Sloan commented that he had identified more than 400 000 ha of barren lands in his 1945 Report and had recommended planting. Orchard contended that there were only 40 000 ha suitable for replanting and two-thirds of this land was in private hands. Neither Dr. Orchard nor Harold MacWilliams, then in charge of reforestation, believed there should be any reforestation in the interior. Allan Moss, representing the Interior Lumberman's Association, was quoted in the Report because of the experimental work he had undertaken for Simpsons in the Okanagan and because he disagreed with the stand taken by the Forest Service.

Sloan made several recommendations in detail. He advocated planting about 20 250 ha each year, 14 580 of these to be on non-satisfactorily stocked lands. He suggested that the Forest Service experiment with planting by scattering treated seed from aircraft, locate small nurseries in areas requiring planting, expand the seed collection program, stop the concentration on Douglas-fir seedlings through more diversified seeding and

demand patch logging rather than depend upon single seed trees to regenerate harvested land. Sloan thought that 1977 seedlings per ha should be planted. In contradiction to Dr. Orchard, he further recommended that an "experimental spruce nursery" be located in the northern interior.

Government reaction was immediate. An extraction plant was located at Duncan to process all coastal seed. A registration program was set up for all seed used in the province. A site for a seed orchard was purchased at Duncan to grow high elevation Douglas-fir seed which was difficult to collect; 'plus tree' nursery stock was secured from appropriate sites. The unusually high cooling sprinklers readily identify this orchard. Sprinkled cold water slowed seed development in the spring so that low level pollen did not contaminate the high level orchard stock.

In the interior, three pilot plantations were established in the Prince George District using spruce and Douglas-fir seedlings from Green Timbers. Another plantation was located at Telkwa in the Prince Rupert District using the same seedling source, and one in Kamloops using seedlings from the East Kootenays. Small nurseries were located at the Ranger Stations at Hixon, Fort Fraser and Telkwa and staffed by the Reforestation Division.

Most of the early interior reforestation trials were located on old burns which had not restocked. Even though the old diameter timber sales were not fully stocked, they had brushed in to the point where planting was not practical. Single tree selective logging, introduced in 1953, was satisfactorily stocked and did not require further treatment. By 1962, logging techniques had changed to allow for leave strips or patches, seed blocks, or sometimes just single seed trees. However, the accumulated slash and exposed margins led to bark beetle infestations, and it became necessary to salvage the leave strips, broadcast burn the entire cut area and plant. The logging trend gradually concentrated larger clearcuts which could be broadcast burned or scarified so they could be planted promptly.

In the years following the second Sloan Report, forest companies that had been awarded Tree Farm Licences greatly increased their planting of seedlings. Not only was this required in the management contract, but the planting of barren or NSR lands to make them more productive increased the annual allowable harvest from the licences. Cutover lands regenerated much more quickly if they were slash burned and planted before secondary growth could become established. In some years up to 90% of the available seedlings from the Forest Service nurseries were planted on private lands or by companies on their licences. Government was criticized by the Public Working Circles for not planting more seedlings on Crown Lands.

Selective seed gathering is a relatively slow procedure. When the bumper 1959 seed crop occurred, the Forest Service collected almost 10 000 bushels, industry about 5000, while independent seed dealers gathered in more than 100 000 bushels. When one is not responsible for the seeds collected, quantity and not quality becomes the motivator. Under such a situation it is difficult to convince the general public that there is a shortage of seed for nursery purposes. The uninformed do not realize that seed sources must be matched to planting areas by location, elevation and tree species.

Starting in 1960, a cooperative forestry work program was developed by the Forest Service and the Attorney-General using selected, non-risk men from the prison system. A gradual expansion in numbers of men, averaging 700, and areas of employment throughout the province took place for the next 15 years or more. Nurseries benefitted in many ways. Land was cleared, cones gathered, trees thinned and pruned, seedlings planted, access roads cleared and seedbeds prepared. The first camp was located in the Chilliwack River Valley. This proved so successful that a second, larger nursery was opened two miles farther up the valley. Similar camps were located in the Sayward Forest, at Rayleigh north of Kamloops, at Haney and near Prince George at Hucha Lake.

Through the 1960s, seed collection, storage and segregation at the Duncan nursery became more sophisticated and continued to expand. For example, in 1962 3246 kg of seed were stored in 832 different lots. By 1970 the stored volume of seed reached 19.75 tons. In that same year 2 million kg had been collected, with half coming from Prince George; 400 000 kg of this new seed was lodgepole pine. Only a few years before, this species was considered non-merchantable and now it is being planted in British Columbia and Scandinavia.

Throughout the early 1960s, the nurseries were hard pressed to meet the increasing and different demand for seedlings. As high elevation planting increased, seedlings raised on the coast had to be placed in cold storage until conditions in the planting areas were favourable. The same problem was encountered with producing stock for the interior until new nursery sites could be developed. Building the required cold storage facilities diverted funds from increasing seedling production.

Even though new records for planting were set nearly every year in the early 1960s, the demand for planting stock continued to exceed supply, and, except for the interior, the Forest Service was not able to plant a high percentage of the identified acreage compared to what the companies were able to plant. To secure the kind of seed required, new attention was paid to locating suitable sites of immature trees, thinning and pruning those chosen to be retained and grafting from 'plus tree' stock. This process required learning, and not all experience was positive.

The expanding program of planting required changes in work procedures. In the interior, from the beginning, Rangers assumed responsibility for organizing planting in their districts. From 1962 Rangers handled this task throughout the entire province, and Forest Service projects increased. The Reforestation Division concentrated on seedling production, area identification for treatment, and supervision. The new sense of direction led to a decision in 1965 that, in future, at least one-third of all cutover lands must be planted. Not considering any backlog, this meant that more than 60 750 ha would have to be planted each year. It was estimated that this would require an annual nursery production of at least 75 million trees. First plans were to reach this goal by increasing plantings by 4 million seedlings each year. By 1968 demand dictated that the program would have to be telescoped, from which came the slogan "75 by 75."

Once the program was accepted, immediate attention had to be given to increasing nursery production by opening new sites and mechanizing procedures. Red Rock was acquired just south of Prince George in 1966 and opened the next year as Perry Creek was being abandoned. Aleza Lake also closed. Trade of land from Green Timbers, concluded in 1968, resulted in a new Surrey nursery, located close to the international border. The second site at Chilliwack was cleared in 1967, and land was acquired to replace the Quinsam nursery at Campbell River which could not be expanded. An addition to the Koksilah nursery was also opened that year. Eight nurseries were now at or near production. To speed seedbed planting, all nurseries used drills for sowing by 1969.

Contract planting by bids had been introduced in 1968, but even this innovation did not eliminate planting problems. Costs were increasing, and there were limitations on the number of staff who could be employed. Using bareroot stock, the weight of the bundles and the use of the mattock on rough ground demanded physical strength and endurance.

The Forest Service was concerned about survival rates on rough, gravelly ground often found on side-hill planting sites. At Squamish, one particular site had been planted repeatedly with no success. Mudpacked seedlings were tried to see if better results could be obtained. Logistical problems relating to weight and ease of planting were not bettered, but survival rates did improve as the technique was modified.

During this exciting period of experimentation and expansion, Jack Walters at the University of British Columbia was exploring a revolutionary method of growing and planting seedlings. In the university forest at Haney he grew individual seedlings in small plastic bullets. The theory was that when these were thrust into the ground the sharp point would penetrate and then crush, allowing the roots to become established in the soil. It was believed that these bullets might even be released from the air in some cases. Walters had grown and done planting trials on comparatively flat ground at Haney. The Forest Service experimented with 50 000 bullets in the Duncan nursery and planted these on side-hill plots on Vancouver Island. It was found that the roots were constricted by the plastic casing, and survival rates were not satisfactory.

Other experiments, conducted at the Pacific Research Centre of the federal Department of the Environment in Saanich by a group of federal and provincial foresters under Jim Kinghorn, demonstrated that seedlings grown in styrofoam containers and then removed and planted as 'plugs' appeared to be a viable reforestation alternative to planting bareroot seedlings. Duncan carried on experiments with this type of production to gain experience and to secure comparison with mudpacks and plastic bullets. The decision was

made to expand container production and prepare nurseries accordingly. At first, the work was all performed outdoors, but gradually greenhouse production was introduced.

There was worldwide interest in what was being done in British Columbia. At a conference in Munich in 1970, Jack Walters demonstrated the work he was doing with plastic bullets and also referred to the container experimentation being undertaken by the provincial and federal governments.

The production of containerized seedlings proved to have many advantages. It was found that success with reproducing hemlock and spruce was much improved. When the plugs were packaged in wrapped bundles of 25 they could be easily handled by women. The tool used to insert the plugs in the ground was not heavy, nor did it require strength to operate. As a consequence, an expanded and improved labour force for planting could be recruited from women.

By 1971 the provincial government could also reflect pride in the new planting records that were being established almost every year. The Forest Service was now planting, on a consistent basis, more trees than industry for the first time since 1953. The Forest Service production increased from 6.3 million in 1968 to 24.6 million.

In May 1972 a nursery site was located at Skimikin, near Salmon Arm, to focus on the container production of seedlings. That same spring the legislature passed the requirement that every licensee of Crown Timber had to reforest the land from which timber was cut. This transferred responsibility, except for supervisory duties, from the Forest Service to the licence holder. The following year a suitable site for a container nursery was located at Harrop near Nelson.

In 1974, scarcely four years since the experimental planting from containers was started, more than 17 million such seedlings were produced — a remarkable achievement. Production was then concentrated at Surrey, Koksilah and Skimikin nurseries, and at the Vernon Ranger Station. Pilot trials were proceeding at Red Rock and Telkwa, and new container facilities were being installed at Green Timbers and Campbell River. For the first time on record, the demand for bareroot stock declined when container seedlings were available. There were still problems of production to be overcome with hemlock and Douglas-fir seedlings, but these proved to be minor in the light of the progress which had been made.

This review of the early history of reforestation in British Columbia concludes with some facts. By 1975, 91 million seedlings were produced in the nurseries — well over the targetted 75 million. Mudpacks and bareroot stock were not completely replaced by containers. There remained particular sites which required seedlings of these types before reproduction was possible.

Securing funds for growing trees is always difficult when in conflict with other demands made upon government for such matters as health, social welfare and education. Treasury Board does not even give serious consideration to resource expenditures until after the more demanding departments have their budgets finalized. From the time the Reforestation Division was given a separate vote in 1947, the annual vote wavered around the \$400 000 figure until some modest increases were added from 1961 to 1967. Above the voted sum there were funds for nursery development from a Federal-Provincial Forestry Agreement.

The accelerated reforestation program in 1968 required a special appeal. A vote of \$859 000 was secured to establish the new nurseries with their expanded seedbeds. No mention was made at the time that once the increased seedlings were in the beds they would have to be planted the next year, and this would create an additional cost on an annual basis. A Forest Service report stated that in the following years funds were voted more or less as requested, with the exception of the capital program. Securing the actual vote was not that simple. Treasury Board accused the Minister responsible of not disclosing the automatic impact of passing the increased vote the year before. The stand-off was that either the seedlings would be planted or they would have to be destroyed. It did not have to be emphasized what the political consequences might be. The vote was passed as requested and some other project had to suffer.

British Columbians can take pride in the contributions their forest workers have made to the development of techniques for reforestation. No other jurisdiction can be credited with such an advance in such a short period of time. The 1960s proved to be a remarkable period for progress. Many of the procedures developed in this province are now accepted throughout the forest world without any thought as to who was responsible for their development. When all work toward a common goal, it matters little who gets the final credit.

Ecological Implications of Successional Manipulation

by
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Ecosystems are continually changing as a result of the evolution of new species, the spread of existing species or climatic change. More commonly, it is the result of the recovery of an ecosystem following some disturbance — such as windblow, insects, disease, fire or forest harvesting — which removes the previous biotic community.

Ecological succession is the successive replacement of one biotic community by another on an area of land following a disturbance of the previous community, this sequence continuing until a relatively stable, self-reproducing **climax** community is formed, or until a subsequent disturbance, whichever comes first. Accompanying changes occur in microclimate, forest floor, mineral soil and forest productivity (Figure 1).

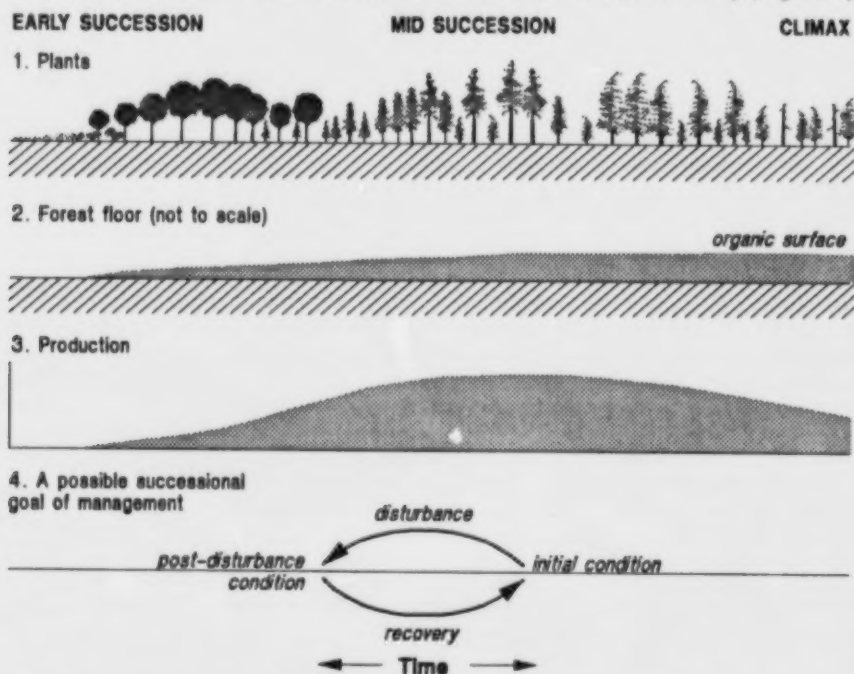


FIGURE 1. Changes in community structure, forest floor depth and productivity over a hypothetical succession, and a possible successional objective of management (in this example, to maintain the ecosystem in a late seral condition).

In some ecosystems, maximum production occurs in the climax seral stage, but for many ecosystems, the maximum productivity of the most desirable tree species occurs in a mid-seral or sub-climax stage of ecosystem development. In the former case, it may be desirable to minimize ecosystem disturbance at the time of harvest and post-harvest site preparation. In the latter case, it may be desirable to disturb the ecosystem sufficiently to sustain a mid-seral condition. The difficulty is to ascertain the proper degree of disturbance which maintains optimum seral condition in the long run under the influence of natural or management-assisted successional recovery and future management-related disturbance.

PATTERNS OF SUCCESSIONAL CHANGE

Successional sequence following harvest of the previous tree crop or some other disturbance falls into three major patterns (Figure 2):

1. facilitation pathway;
2. tolerance pathway; and
3. inhibition pathway.

PATTERNS OF SUCCESSIONAL CHANGE

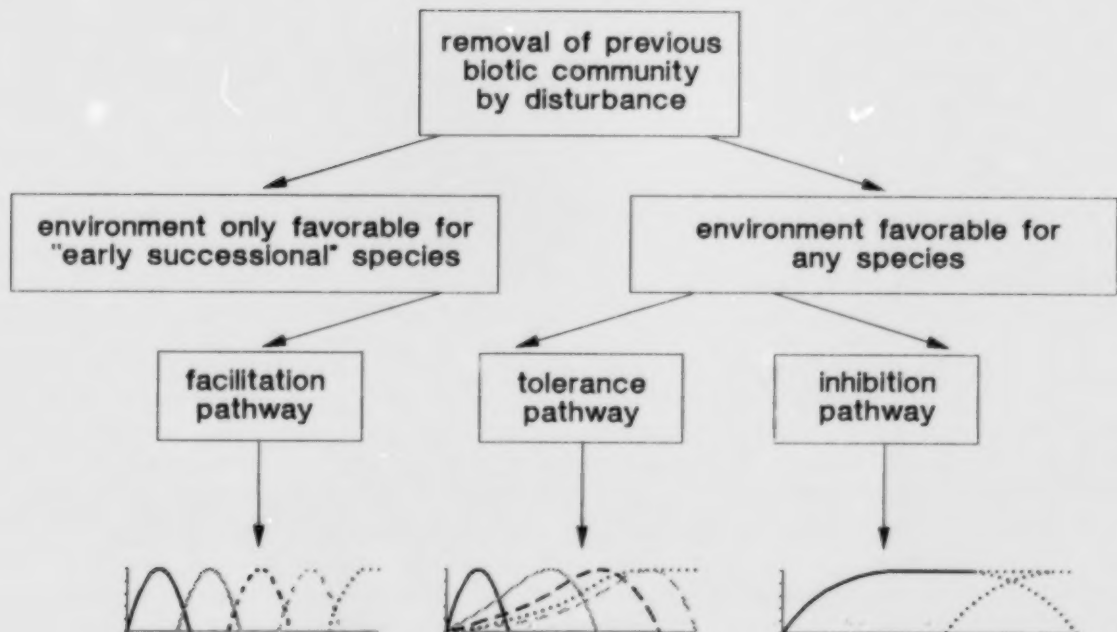


FIGURE 2. The three-pathway model of ecological succession (based on Connell and Slatyer 1977).

The facilitation pattern of succession occurs in those post-disturbance environments which are suitable only for "pioneer" colonizing species because some aspect of the ecosystem has become intolerable for later successional species. The pattern involves a fairly predictable sequence of biotic communities, each of which "modifies" the ecosystem making it more suitable for the subsequent community.

The two other pathways are initially suitable for many species. In them the sequence of plant communities in the succession depends upon the particular mixture of reproductive propagules (seeds, spores, buds) on the site after disturbance. In the tolerance pathway, early successional communities may slow down but do not prevent the growth of the species of later seral stages, and do not prevent the eventual development of mid- and late-successional communities. Succession proceeds, albeit more slowly than it would without this competition/interference from early seral species. In the inhibition pathway, early seral species can completely inhibit the development of later successional communities, delaying succession.

A manager faced with the facilitation pathway in areas to be regenerated may be unwise to eliminate the early seral stages unless prepared and/or able to compensate for the absence of their modifying effects by such things as fertilization or microclimatic modification. Where one is faced with the tolerance pathway, weeds may slow attainment of "free-to-grow" status, but aggressive weed control may not necessarily be economically justified, since the crop will eventually grow large enough to dominate and suppress the weeds. Considerable increases in potential crop value would be required to justify significant investment in vegetation management.

In contrast, a manager faced with an inhibition pathway succession may have to manage the non-crop vegetation if economic crops are to be developed on the site soon enough. The inhibition pathway can develop from either of the other pathways if one seral stage is permitted to become too well established on a site.

Clearly, the manager must be able to recognize both the successional implications of the harvest-induced disturbance (in terms of degree of successional retrogression) and the type of successional pathways that will result.

EFFECTS OF MANAGEMENT OF SUCCESSION

Forest management disturbs succession, inevitably and often deliberately. It can either advance (accelerate) successional change towards climax, delay (retard) succession or reverse it (successional retrogression). The desirability of the disturbance will depend largely upon its successional effects relative to the successional goals of management.

Following harvesting, with or without site preparation, silvicultural activities may either avoid or exacerbate succession-related management problems. Delayed planting and/or the use of low vigour or inappropriate species/stock type of seedlings can permit non-crop vegetation to "capture" much or most of the "leaf area" carrying capacity of the site (Figure 3) and interfere with crop tree growth severely. It can also result in the benefits to seedlings of the "assart" effect (post-harvest flush of nutrients caused by accelerated decomposition of the slash and forest floor) being missed (Figure 4). This can result in poor early growth performance and an increased susceptibility to drought and weed competition. Prompt planting of large (robust, with a good root/shoot ratio), healthy seedlings of the correct species and stock type for the site conditions will generally result in much better early growth and fewer weed problems. Late planting and/or the use of poor quality seedlings (or the wrong species or stock type) can result in development of early seral herb and shrub communities that change the succession pathway from "tolerance" to "inhibition."

Where weed control is practised, early growth of crop trees is usually benefitted. However, rotation-length consequences of loss of organic matter and nutrients which can accompany such control should be considered. If such losses will significantly reduce volume and value of the final crop, less disturbing treatments should be used, or ameliorative actions (e.g., fertilization) should be considered to compensate.

Management can also result in successional desynchronization. A seral stage is defined by its biota, its microclimate and its soil conditions. Clearcutting with minimal soil disturbance can result in an early seral microclimate but a late-seral forest floor/mineral soil condition, making it difficult for any plants not already established to invade. This desynchronization of microclimatic and soil conditions can be rectified by a site preparation treatment such as burning or scarification. However, if such soil treatments are inappropriate for the site, or the desired crop species, harvesting may have to be modified to reduce the degree of microclimatic retrogression. Whatever happens, different components of the seral stage should be kept approximately in synchrony.

CONCEPTS OF ECOLOGICAL ROTATION

Because some degree of successional management is usually unavoidable and/or desirable, forest managers should consider the concept of "ecological rotation." This is the period of time for a particular type of ecosystem to recover to its original (or to some desired) condition following a particular level of disturbance (Figure 5). If management constraints dictate a high level of successional disturbance, it will probably be necessary to have long rotations or intensive management inputs to assist in ecosystem recovery. If management restraints require shorter rotations and/or rule out intensive ameliorative inputs, site disturbance

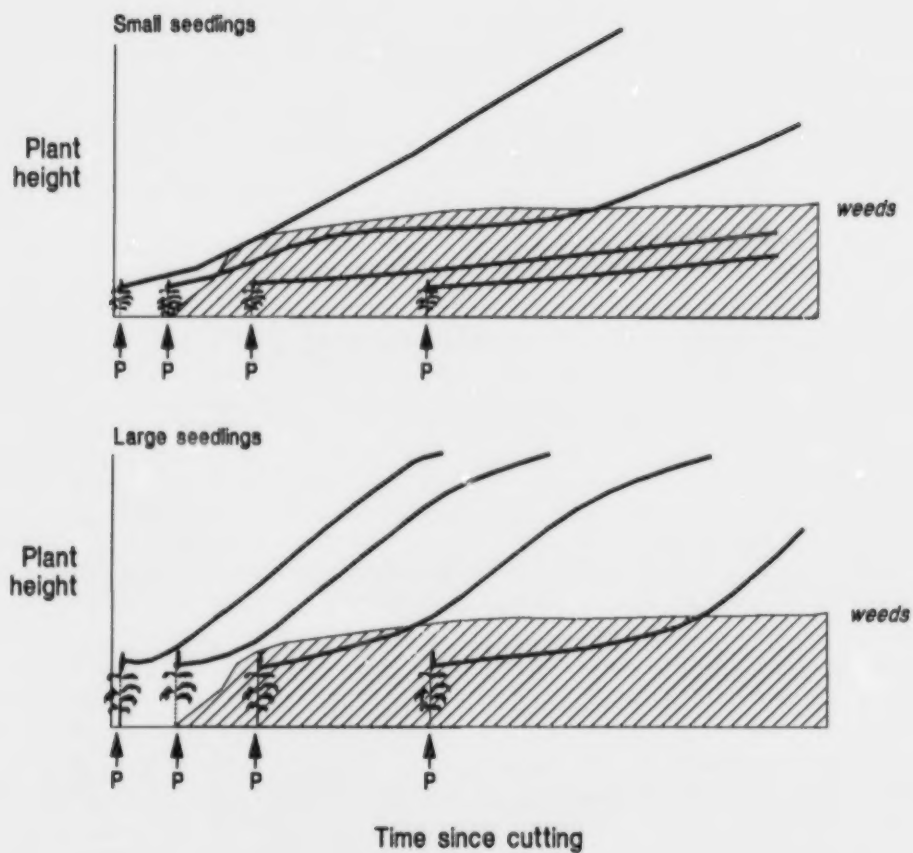


FIGURE 3. The consequences of either a planting delay or the use of large or small seedlings on initial seedling growth: the effect of competition from non-crop plants (weeds). (P = time of planting)

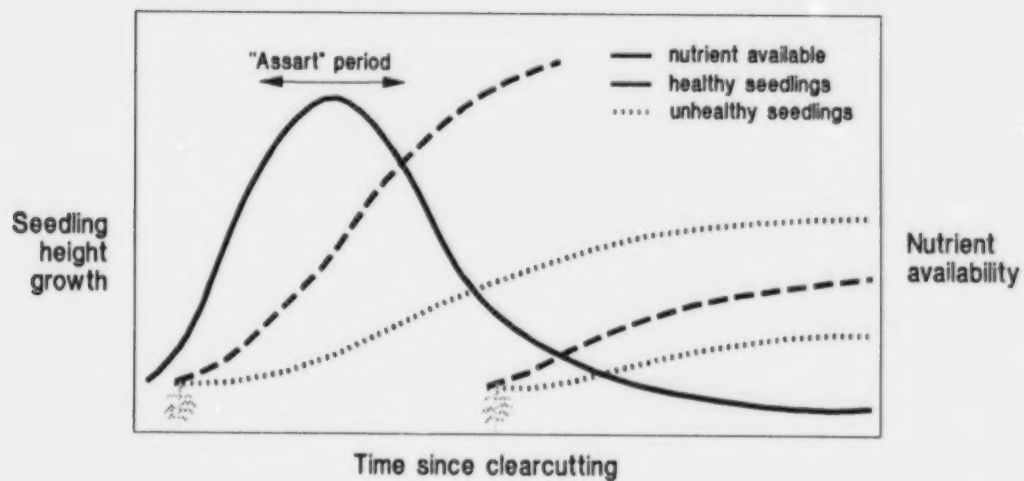


FIGURE 4. The consequences of either a planting delay or the use of low vigour seedlings on initial seedling growth: the effect of missing the "assart" effect.

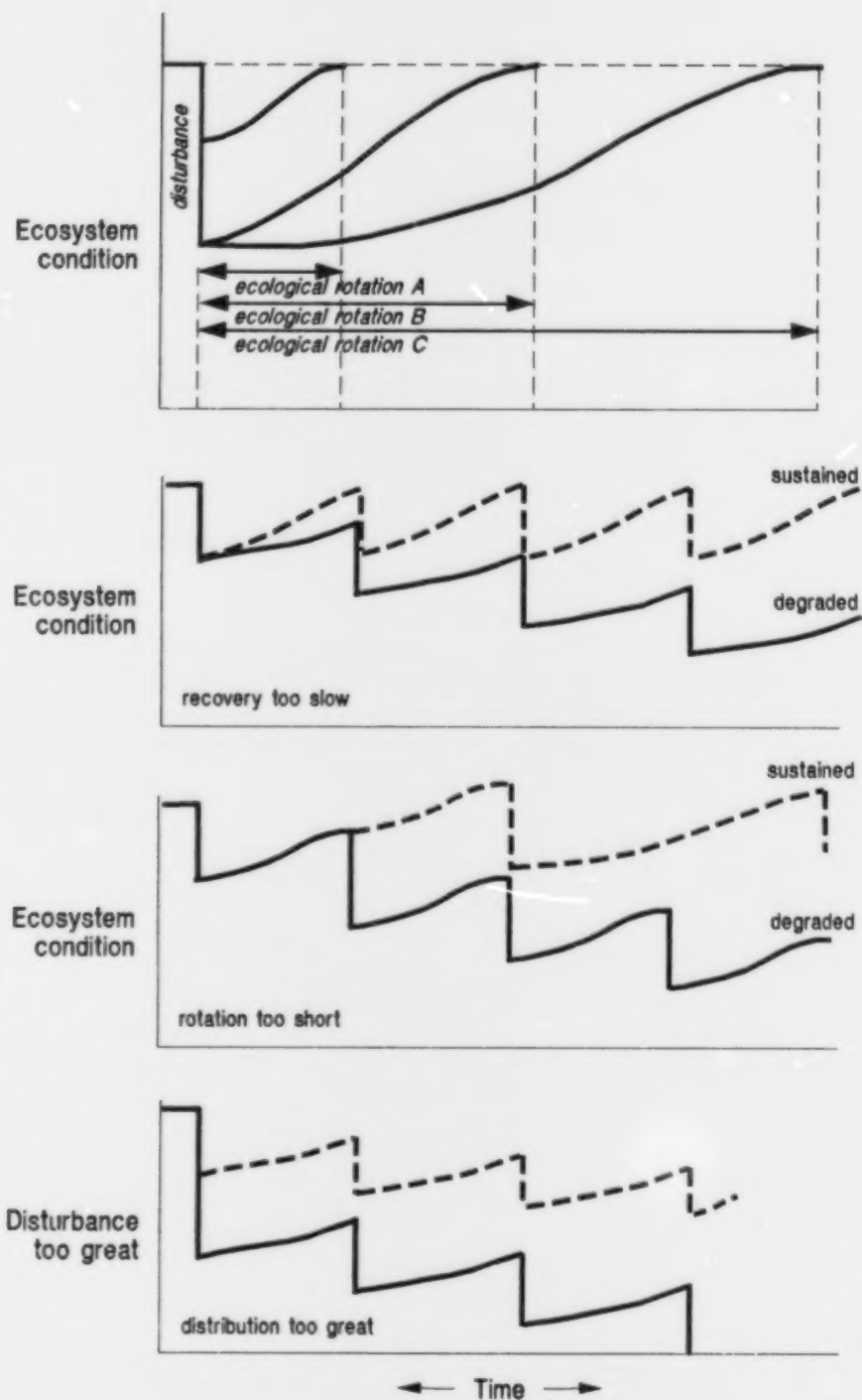


FIGURE 5. The concept of ecological rotation: the time to recover to the pre-disturbance ecosystem condition. The ecological rotation depends on the natural rate at which an ecosystem recovers from disturbance and the degree to which the ecosystem has been disturbed. Ecosystems will be degraded if recovery is too slow, the rotation is too short, or the disturbance is too great relative to the rotation length, degree of disturbance, and rate of recovery.

and successional retrogression must be less, especially in ecosystems that recover slowly. Balance is required between the frequency and intensity of disturbance and the level of management that is economically feasible.

PREDICTING THE YIELD, SITE PRODUCTIVITY AND ECONOMIC IMPLICATIONS OF SUCCESSIONAL MANIPULATION

Whenever possible, consequences of different levels of successional manipulation for yield, site productivity (including long-term implications) and stand-level economics, should be predicted on the basis of empirical field evidence. Where such evidence is lacking, predictions are best made with the assistance of ecosystem-level hybrid simulation models such as FORCYTE-11 (Figure 6).

As an ecosystem model, FORCYTE-11 can simulate the secondary succession of the stand cycle, including facilitation, tolerance and inhibition pathways. It can simulate competition between herbs, shrubs and trees for light and nutrients (a future version will also simulate moisture competition). The "benchmark" version for FORCYTE-11 (due October 1988) will be able to simulate site preparation (mechanical, pyral), regeneration (planting, natural seeding, coppice/root suckering), weed competition and control (chemical, manual, mechanical, biotic, pyral), stocking control and commercial thinning (high, low or random (row) thinning), variable rotation length and biomass utilization, pruning, herbivory (insects on trees, wildlife on understory or domestic livestock on understory or trees) and fire (slashburning or wildfire). It can predict the consequences of various combinations of the above treatments for yield, soil fertility, nutrient budgets, economics and the energy efficiency of management over multiple rotations.

CONCLUSION

Foresters should have a good grasp of successional manipulation. Management-induced successional retrogression can have important implications for volume and economic yields. The ecological consequences of successional manipulations are very complex. Prediction of these consequences should be based on empirical evidence over at least one rotation, but in the absence of such evidence computer models are needed. Ecosystem-level hybrid simulation models such as FORCYTE-11 appear to offer the best currently available succession predictor for use in forest management.

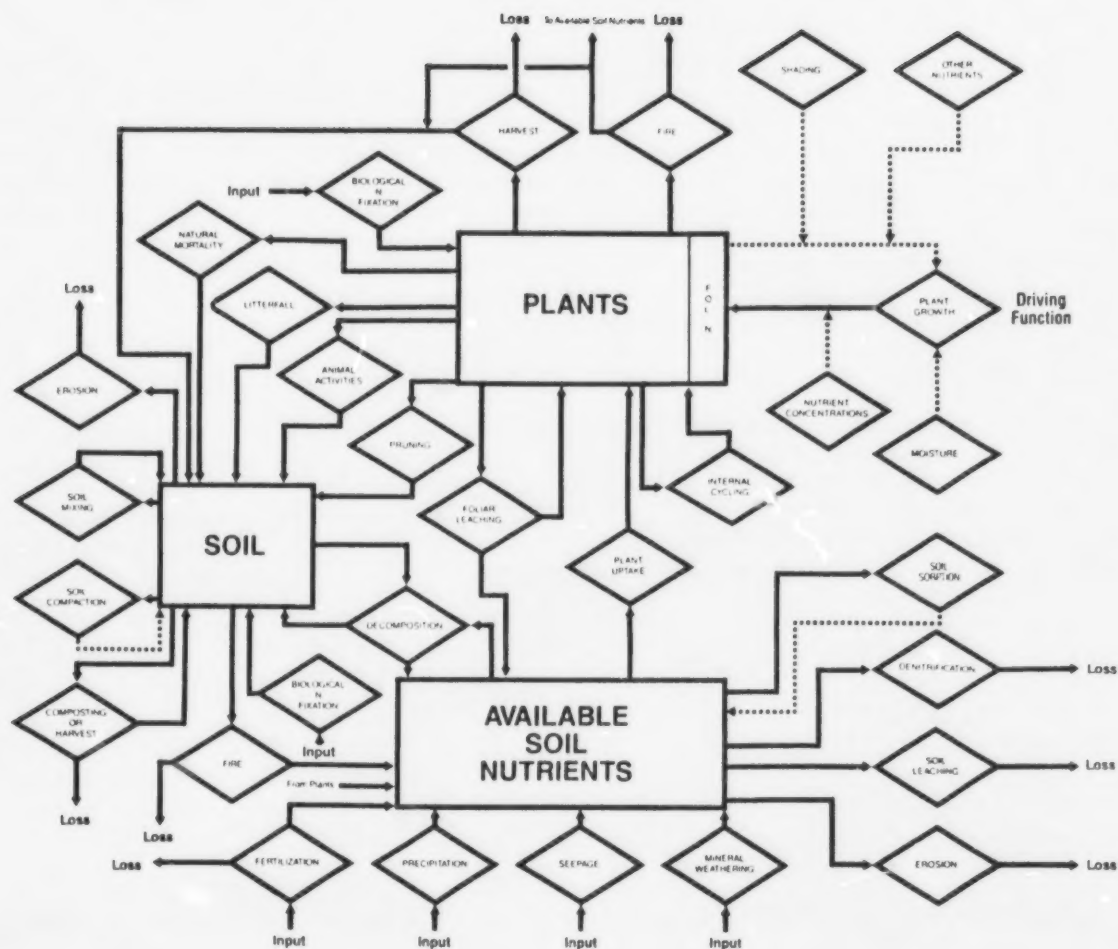


FIGURE 6. Flow chart of compartments and processes represented in the ecosystem management model FORCYTE-11.

Private Nurseries — Past, Present and Future

by
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In 1987, there were 15 private companies (not including licensee nurseries) producing seedlings under contract to the Ministry of Forests and Lands. Every Forest Region in the province with the exception of Nelson had one or more private nurseries. The present productive capacity at these nurseries is approximately 100 million trees, which represents over 50% of the provincial total.

Prior to 1980, the Ministry of Forests and Lands was the sole producer of seedlings for Crown lands (with the exception of Pelton Reforestation Ltd. which produced minor quantities) and provided these seedlings without charge to licensees. The 1976 Royal Commission on Forest Resources recommended that private parties should be allowed to engage in forest nursery activities under appropriate controls developed by the Ministry. The report stated that the ideal situation was for licensees and private nursery owners to enter into long-term private contracts for the production of quality-controlled planting stock.

Section 146 of the *Forest Act* (1978) gave legal authority for Regional Managers to enter into agreements with private nurseries for growing tree seedlings. Nursery policy developed as a result specified that nurseries should be regionalized, both licensees and commercial growers should be involved, and that the cost of stock from private nurseries should not exceed the cost of seedlings produced at Ministry nurseries. The policy called for direct contract between licensees and commercial growers with the cost of seedlings to be recovered through funding under Section 88 of the new *Forest Act*.

Following acceptance of the Private Nursery Policy, production began at private commercial facilities in 1980. While the majority were existing greenhouse operations, several companies set up transplant nurseries to gain experience with growing seedlings. By the end of 1981 there were six private companies producing container stock only (Pelton Reforestation Ltd., Reid Collins Nurseries, World Silviculture, Arbutus Grove Nursery Ltd., Sylvan Vale Nursery and Ruffs Greenhouses), one with both greenhouse and transplant facilities (Industrial Forestry Service Ltd.) and one with only transplant beds (Riverside Nursery). As a result of economic conditions and the reluctance of some licensees to include seedlings under Section 88 funding, the Ministry of Forests developed and entered into five-year contracts with the seven commercial nurseries that had greenhouse facilities. The contracts covered current production levels and allowed for expansion over the term of the agreement. Contracts with Riverside Nursery as well as the transplant crop at IFS were on a year-to-year basis.

By 1986 the private commercial sector had expanded production to nearly 100 million seedlings. This was accomplished by expansion of the original nurseries and also by a Ministry effort to encourage regional development of additional nurseries. As a result, seven new nurseries were awarded five-year contracts for seedling production starting in 1985. Along with expansion came competitive bidding. Prior to 1985 prices were established by direct negotiation with the Ministry. Once competitive bidding was introduced, a procedure was needed to evaluate bids. A Nursery Competency Rating Formula was developed based on two main components: a Delivery Rating (percentage of trees delivered in relation to requested amounts) and the proportion of seedlings above a target root collar diameter.

In 1981, a committee was struck to develop a B.C. Forest Nurserymen's Association, primarily for information exchange on technical matters and for establishing cooperation between Ministry, licensee and commercial nurseries. Membership was open to all nurseries in the province regardless of ownership or affiliation. Friendly rivalry has helped to improve the quality of seedlings produced in the province. As an example, in 1981 the minimum acceptable standard for a PSB 313 Spruce seedling was 1.8 mm root collar diameter while now it is 2.4 mm (a 33% increase).

Commercial-sector seedling producers under contract to the Ministry recently formed their own association. Recent privatization initiatives undertaken by the Provincial Government will result in nine former Ministry nurseries being turned over to the private sector, including six with both container and bareroot facilities.

Over the past seven to eight years there has been a major change in the stock types available within the province. While the bareroot program has remained relatively constant at around 40 million trees and is presently declining, the container program has increased from 60 million to 160 million since 1981.

Now that financial responsibility for reforesting cutover lands is being transferred directly to the licensees, interest is being shown in stock types that have not been recently available through the Ministry. As an example, the container transplant program has shown that these seedlings perform very well and that for certain sites this stock type is very desirable. This has led to orders for almost 2 million transplants to be sown in the spring of 1988 at the IFS nursery. With less direct government control on prescriptions, stock types not available during the past few years may be prescribed if silviculturists feel that they will perform best on the plantation.

The new system of direct contact between nurseries and licensees will be very positive for both parties. Through consultation and cooperation it will be possible to match seedling characteristics to the planting site. Any system that promotes communication between the field forester and the nursery is bound to have a positive impact on the reforestation effort.

Seedling Production for Northern Operations

by
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This paper is a summary of observations at our nursery while growing container stock for northern operations. My objective is to communicate a nurseryman's understanding of seedling requirements for successful plantation establishment.

SEEDLING SIZE SPECIFICATIONS

Light per Seedling is All Important

Figure 1 shows the amount of light per cavity for the major styroblock types and the seedling root collar diameters that result. Seedling costs are also related to block yields per square foot of greenhouse. There is a linear relationship for size and cost expectations as the light per seedling increases. In the seedling size vs. cost squeeze, field foresters should understand the light/size relationship and how their size specifications will affect block size choice and seedling cost.

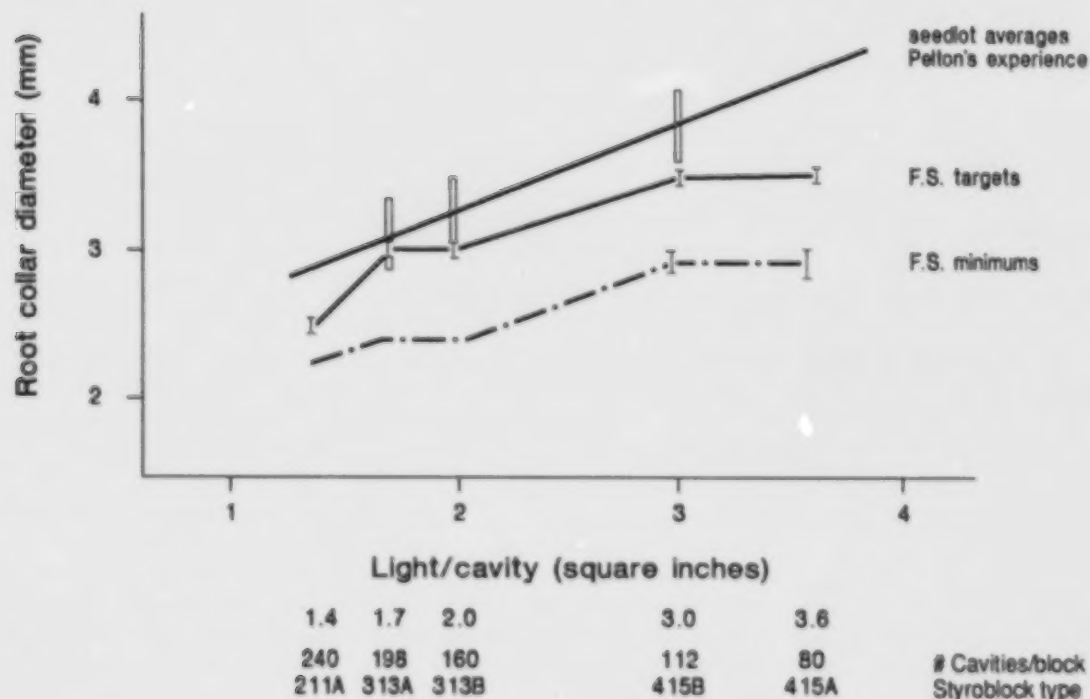


FIGURE 1. Seedling diameter expected by styroblock container.

The main advantage of larger cavity size is seedling momentum for occupying brushy sites. We believe that larger stock will be cost-effective by providing better early growth and better survival on such sites. Larger stock should reduce the number and amount of brushings required and allow fewer seedlings per hectare to be planted with greater confidence of establishment.

DELIVERY SEASON EXPECTATIONS

Balanced Seedling Growth = Successful Plantations

Improved culture and additional stock types now allow us to deliver seedlings physiologically tuned to your planting window throughout a 90-day planting season for northern operations. Our stock delivery schedule is shown in Figure 2. John Revel's work indicates that winter-stored seedlings cannot be planted later than 15 June with any assurance of effectiveness.

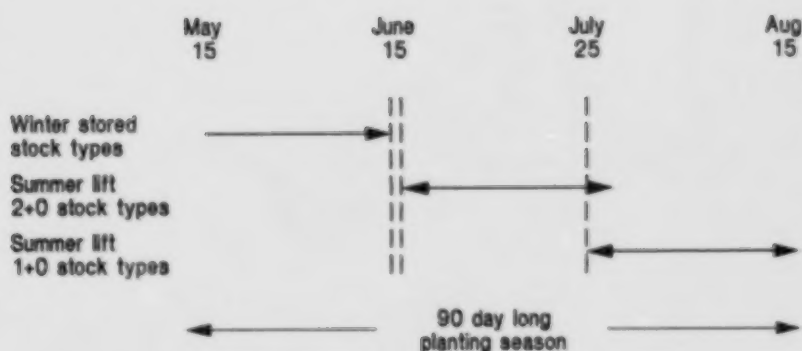


FIGURE 2. Seedling delivery schedule to meet planting windows.

The objective in selecting a stock type for your planting window should be to establish the seedling's "balanced access to resources" in the first season. This ensures good root growth for access to water and nutrient before the luxuriant top growth demands them. First winter survival requires effective completion of top growth, root growth and hardening-off cycles. Subsequent years' growth effectiveness depends on successful acclimation during the first plantation year.

Trials with summer planting seem to indicate that the earlier the planting, the better, and that planting can continue until soil temperatures drop below about 12°C.

SEEDLING QUALITY EXPECTATIONS

Timing Is Everything

Seedling quality derives from the nursery's manipulation of light, temperature, moisture and nutrient over time within the natural cycles of coniferous plants. For quality seedling production, timing is everything. Timing starts with timely delivery of seed and continues through growing phases to harvest, delivery and planting of seedlings. Figure 3 shows our understanding of the time relationship between cycles.

First, the growth/dormancy cycle is a horizontal sine wave over time. Up on the cycle is toward unrestricted top growth; down is toward dormancy or physiological shutdown in preparation for winter. The cycle starts at spring budbreak (SBB) when the bud flushes and increases linear extension rate exponentially. At maturity index (MI) leader extension becomes sensitive to day length. Growth slows and the leader straightens up. By vegetative maturity (VM) terminal buds are formed, visible and light brown. Top growth has stopped and the seedling continues toward dormancy. In this interval of lengthening night and cooler temperatures, seedling body and dry weight increase as diameter, root and leaf primordia grow and needles become waxy, cells lignify and reduce water content, and roots suberize. At deep rest (DR) seedlings reach their physiological stop point for the year. Photosynthesis has almost stopped and roots are stopped. Then the seedling begins to reactivate, with photosynthesis building almost to summer levels and root growth bursting prior to spring budbreak, and the cycle repeats again. Increasing day length, light intensity and warm nights divert the seedling's energy toward top growth.

Second is the nursery/plantation relationship showing the approximate stages at which seedlings should be outplanted, depending on the planting season.

Third shows how height and root collar diameter (RCD) relate to the timing cycles. Height makes a small leap as the seed germinates, then increases exponentially through MI and slows to stop by VM when buds are formed. Root collar diameter's exponential growth occurs about the time of VM and continues, within heat and light constraints, until just before DR. If a seedling is to meet RCD objectives, vegetative maturity must be induced early enough in the summer to ensure sufficient photosynthetic light and heat for seedlings to complete the energy-intensive hardening-off process.

Fourth shows that relative root growth parallels the RCD curve until just before DR when it drops to zero. Root growth stops in preparation for winter. Between DR and SBB root growth becomes opportunistic as temperature and available plant energy allow. As top growth begins at SBB, most plant energy is diverted to the top and root growth slows dramatically. It then increases again as top growth slows after MI. The two big bursts of root energy are in the late summer following VM and in the spring just prior to SBB.

In our nursery, with 2+0's, root growth is active in late February, slows with top growth in March through May and bursts again in June through September, provided adequate moisture levels are maintained.

Fifth shows that temperature stress resistance for tops cycles throughout the year with minimum stress tolerance following SBB through MI. At this time, temperatures in the +5°C range may cause disorienting stresses to seedlings. Stress resistance increases so that some frost tolerance is achieved by VM and a maximum is reached some time after DR. Resistance is greatest during winter but decreases very rapidly just before SBB.

Sixth shows water stress resistance in tops and roots, as measured by the pressure moisture stress system. In tops, tolerance for moisture stress is least during active top growth, when needles are softest. As needle body and waxiness increase through VM, stress resistance increases and is maximum after DR. Root stress resistance is also least after SBB (presumably related to the plant's great need for water to support top growth). Root stress resistance is greatest in mid-to-late summer, near and following budset (VM).

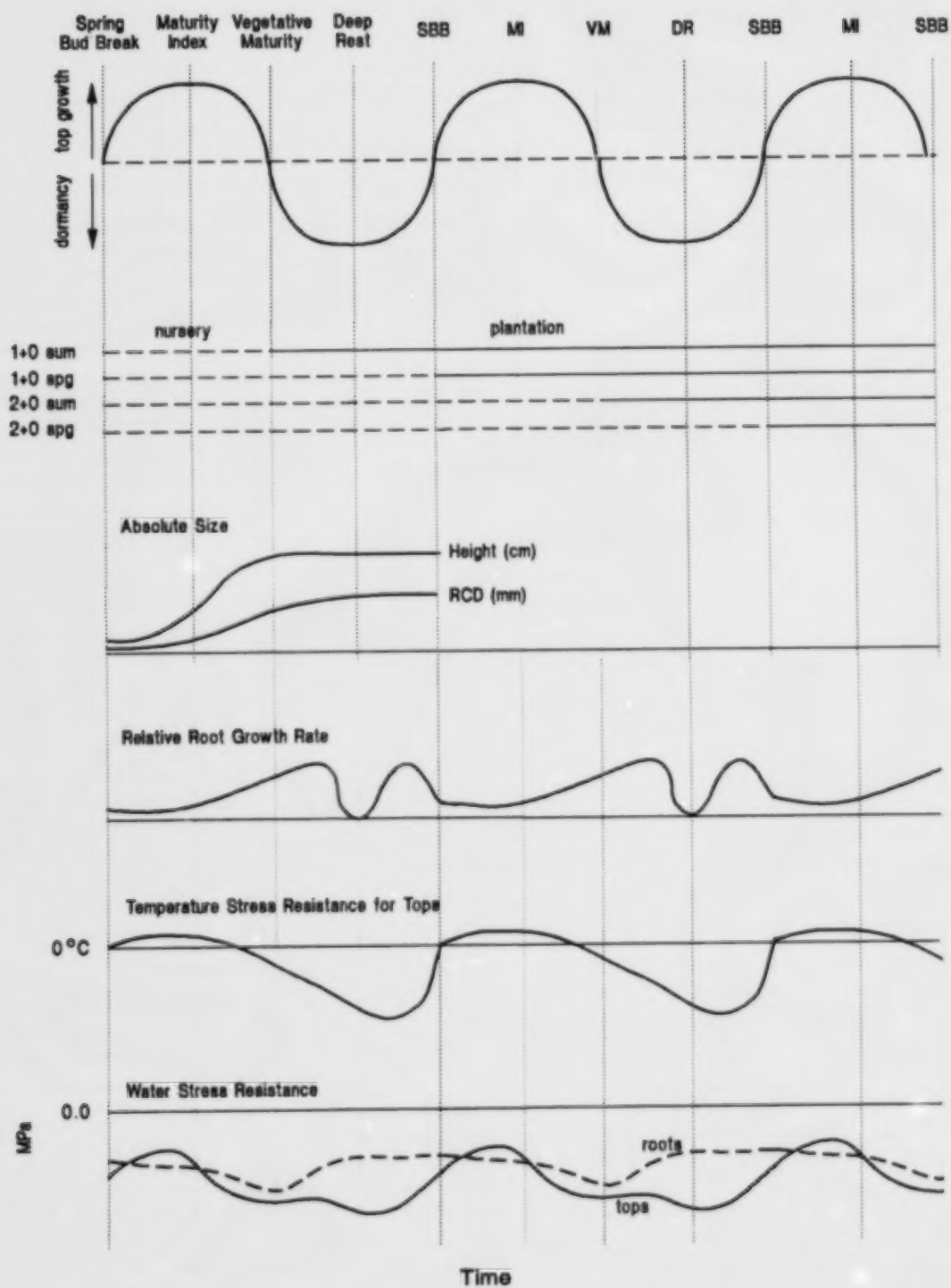


FIGURE 3. Timing is everything.

SELECTING STOCK TYPES FOR YOUR PLANTING WINDOW

Physiologically Tuning Seedlings for Effective Plantation Performance

As a general objective, we want root growth before top growth for balanced access to resources in the critical first growth year. To achieve that what must we do?

For spring planting, 15 May through 15 June, we want stock with high root growth capacity at time of planting. To achieve that we must time the seedling's cycles so that DR occurs just before the scheduled lifting. The seedling must be stored cold, below +2°C, since heat accumulation during storage may make SBB occur too quickly after planting. The seedlings must be planted as soon as possible after snow melt to allow time for root development before rising night temperatures and high light levels speed onset of SBB. Effectively timed spring planted stock will have a root growth phase on the plantation site before top growth begins.

Seedlings planted after 15 June will usually have a top flush without a root growth period and will encounter early fall cold temperatures. This would cause a disorienting sub-lethal stress, causing reduced hardiness development and stress resistance the first fall. The next spring, as temperatures increase the seedlings will move too early into SBB. Such seedlings are then desiccated by late spring frosts or degraded into a lasting stress cycle. Such seedlings may have two or more top growth phases before an effective root growth phase. Five years may elapse before the roots and tops can achieve balanced access to resources.

For summer planting, 15 June and on, we need seedlings that have already completed their spring top growth at the nursery and will move through their hardiness development stage in the plantation. Such seedlings already have some cold temperature resistance and can move through their major root growth periods on the plantation. Summer planted seedlings will have two root growth phases before a top growth phase.

CONCLUSION

Effective Plantations are Our Goal

Assurance of effective plantations requires that we all understand the natural cycles. Field foresters must know what planting windows and stock size parameters will meet their plantation's requirements. Together with nursery staff, they can design physiologically prepared seedlings, tuned to their site conditions, which will produce effective plantations.

Stock Types for Planting - What's Available, What's Required

by
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THEORY FOR SUCCESSFUL REFORESTATION

Selection of stock types for planting must be based on sound ecological and silvicultural principles, research information, local knowledge and economic criteria. The four major vectors for successful reforestation are:

1. silviculture prescriptions;
2. site preparation;
3. seedlings and planting; and
4. plantation maintenance.

Butt (in preparation) identified factors responsible for plantation failure, including poor or non-existent prescriptions, lack of site preparation, excessive regeneration delay, improper stock types, poor quality stock, poor planting site selection and insufficient brushing and weeding. The selection of the proper stock type or, for that matter, the creation of a new stock type to perform at a predictable level, must receive due attention. Considerable efforts and dollars will be expended in prescribing, preparing, planting and weeding rehabilitated areas, so selection of appropriate planting stock is important.

STOCK TYPES AND SIZES: THE EARLY YEARS

While stock types generally reflect a particular nursery culture, age and growing environment (e.g., 2+0 bareroot, PSB 313 1+0, 1½ + 1½ transplant), foresters tend to think of morphological size and ignore physiological factors.

Prior to 1961, there were no standard size requirements or targets for the nursery. Seedling standards were the nursery's choice, and each year's crop differed. The basic stock type being grown was bareroot 2+0.

Throughout the 1950s, many studies were conducted using height classes of stock relative to survival and height growth after planting as an approach to testing stock standards. Results indicated that better plantations resulted from bigger planting stock.

In 1961, a major problem analysis and field testing was carried out on interior spruce. By 1971, the results supported stock sizes for a variety of bareroot stock types. Plantable bareroot spruce had a minimum of 10 cm x 2.4 mm (except for a reduction to 8 cm if the caliper and root mass were "heavier"). Base stock for 2+1 transplants had a minimum of 7 cm x 1.5 mm and a maximum of 9 cm x 2.3 mm (a maximum for planting machines). And for 2+2 transplants, the base stock could be no smaller than 5 cm x 1.2 mm. Through the 1970s, these were the bottom-line standards for spruce, and more often than not, seedlings were not much bigger than the minimums.

While foresters struggled with inferior stock, a new planting stock, container-grown seedlings known as "plugs", was being developed in a joint venture between the B.C. Forest Service and the Canadian Forestry Service to produce more seedlings at less cost with less space and lower risk of loss, both at the nursery and on the cutover. As it entered full production in the early 1970s, so did the contest of what stock size did best under what conditions.

FROM MINIMUMS TO TARGETS

"Targets" rather than "minimums" evolved as the basis for foresters to decide upon what to order. In 1974, attainable target sizes for Styro Plug 2 (PSB 211) were reported (Van Eerden 1974) (see Table 1).

TABLE 1. Target sizes for Styro Plug 2 (after Van Eerden 1974)

Region	Species	Height cm	Root Collar Diameter mm
B.C. Coast	Fdc	14	2.5
	Hw	16	2.5
	Ss	14	2.5
	Hm	12	2.0
	Fg	10	3.0
B.C. Interior	Sw	14	3.0
	Pl	10	2.0
	Fdi	12	2.5
	Lw	14	3.0

TABLE 2. Target specifications for planting stock - Prince George Forest Region - by species and planting site classes

Species	Site Class	Height (cm)	Caliper (mm)	Top/Root Ratio	Suggested Stock Types	Expected Survival, First Year
Interior Spruce	Average (Mesic)	22	5.0	2.0:1	Br 2+1	75%
					PSB 211+1	70%
					PSB 313	65%
					Br 2+0	90%
						45%
	Easy (unrestricted)	18	3.5	2.0:1		70%
					PSB 313	85%
	Severe (brush)	30	7.0	1.0:1	PSB 415	80%
					Br 2+0	40%
					Br 1.5+1.5	90%
					Br 2+2	65%
					Br 2+1	75%
Lodgepole Pine	Average (Mesic)	15	4.0	2.5:1	Br 2+0	85%
	Easy (unrestricted)	12	3.0	2.0:1	PSB 211	92%
Douglas-fir	Average (Mesic)	20	5.0	2.0:1	PSB 211	65%
	Easy (unrestricted)	15	4.0	2.0:1	Br 2+0	50%
	Severe (brush)	25	6.0	1.5:1	Br 2+1	40%

By the late 1970s, particularly in the Prince George Forest Region, the urgency to improve plantation survival resulted in a push for larger spruce seedlings both in bareroot and container culture. In 1980, target specifications for various species and stock types were stipulated for the Prince George Forest Region (see Table 2).

RESEARCH AND SX TRIAL RESULTS

Research on the use of alternate stock types, seedling size and site treatment has steered the silviculturist to select specific stock parameters that have proven successful.

Survival and Growth Curves

The graphical data displayed in Figure 1 reflect the performance of different sizes and stock types of spruce seedlings produced in B.C. nurseries planted on relatively fresh logging without site preparation. Invariably, the larger stock does better.

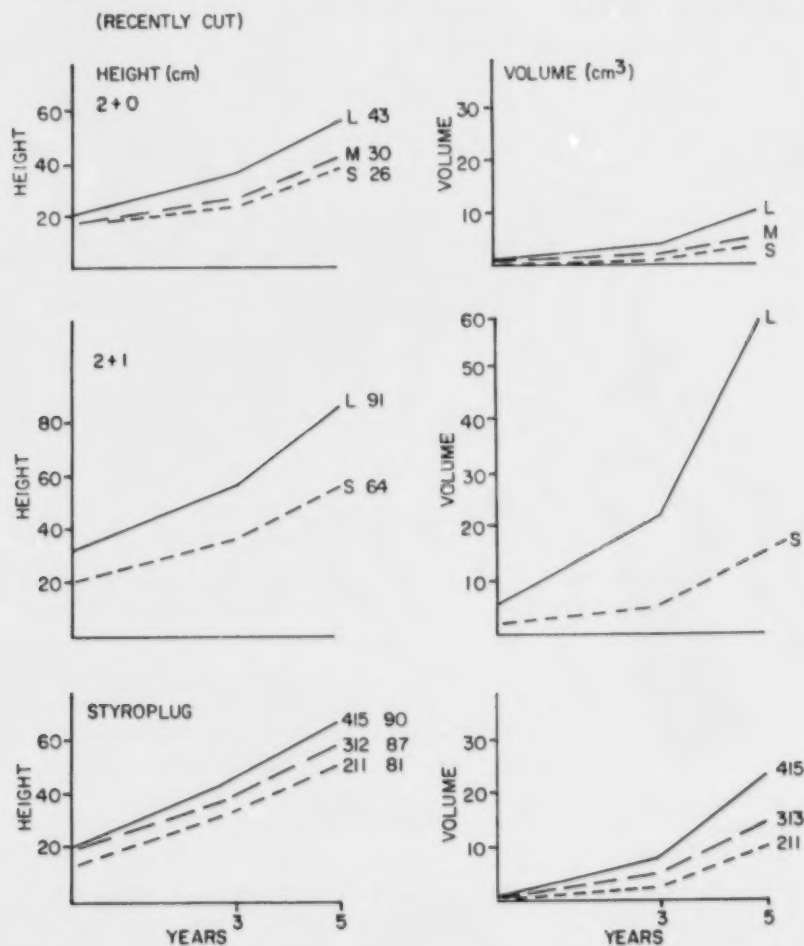


FIGURE 1. Growth and survival by stock type and size (after McMin 1985b).

TABLE 3. Survival and growth by stock type, size and treatment (after McMinn 1985b)

Stock type	Morphological Size at Planting				
	Ht. cm	Diam. mm	Top g	Mass Root g	Total g
2+1 BR	18	5.4	3.9	2.1	6.0
2+0 PSB 415	15	3.4	2.2	0.7	2.9
2+0 BR	17	3.5	1.5	0.4	1.9
1+0 PSB 211	12	1.9	0.4	0.5	0.9

Treatment Stock Type	Survival and Growth at 10 Years		
	Survival %	Height cm	Volume cm
Untreated			
2+1 BR	89	231	1130
2+0 PSB 415	90	240	1331
2+0 BR	75	204	782
1+0 PSB 211	76	181	528
Screeded			
2+1 BR	95	248	1248
2+0 PSB 415	94	238	1142
2+0 BR	87	217	859
1+0 PSB 211	95	199	635

TABLE 4. Five year performance of various stock types of interior spruce (from Van Eerden 1978)

Stock Type	Height cm	Size at Planting		S/R Ratio	Five-year		Ten-Year	
		Root Coll. Diam. mm	Total Weight g		Surv. %	Total Height cm	Surv. %	Total Height cm
211 (1-0)	17	3.4	1.5	1.7	89	60.5	88	200
211 (2-0)	21	5.7	2.1	2.5	96	76.5	92	239
415 (1-0)	22	4.6	3.1	1.8	97	76.8	95	238
415 (2-0)	25	8.7	5.0	2.8	97	91.5	96	278
BR (2-0)	17	3.0	3.1	1.8	49	48.2	48	188
PBR (1+1)	19	5.0	5.5	2.8	74	78.6	71	265

Performance by Initial Size and Stock Type

Size at time of planting and field performance of various white spruce stock types 10 years after outplanting in a moist, fertile spruce site untreated and screefed are shown in Table 3. Notably in these data, initial size is important in growth response. But equally notable is that different stock types of an equivalent size will perform quite differently, as shown by the data for the 2+0 PSB 415 versus the 2+0 BR. It is important to realize that biggest is not necessarily best, but it does help.

Performance of Different Stock Types and Age Classes

Plots of various stock types of Interior spruce were established in 1972 near the McGregor Camp for the Canadian Forestry Service by Van Eerden. Five and ten year data are given in Table 4. Revisited in the fall of 1987, the trial outplanting continues to project the trend of the 10 year data with the 211 (2+0), 415 (1+0 and 2+0) and PBR (1+1) displaying a similar height of up to 8 m but considerable variation among treatments in diameter and survival. When considering both survival and performance on the trial site, the PSB 415 2+0 is the superior stock type. Bareroot stock is disastrous for survival and growth, followed by fair survival and growth for the PSB 211 1+0. Both stock types now receive limited use. The larger stock types perform acceptably, except the plug transplant, which has a poor survival record.

Comparative Data — Spruce Stock Size Trial

The 1987 remeasurement results for SX 84107G are given in Tables 5 and 6 for the Fort Nelson trial location. The trend suggests that the larger classes within the stock type do marginally better. When the survivals are summarized within the caliper and height classes as in Table 7, the results certainly support the use of larger sizes.

Determining the Benefit/Cost of Different Stock Types

With the change in forest policy specific to the purchase of forest seedlings, every forester must examine stock type survival, growth performance, consistency of low failure and purchase cost. Unfortunately, there is no simple, practical way for foresters to determine and assess all the variables that affect the decision on the most appropriate stock type relative to cost/benefit. More emphasis must be placed on the overall establishment costs of forest seedlings, rather than the direct nursery costs. The predictability of stock quality by nursery must also be considered; some nurseries grow consistently better seedlings than others.

The example given in Figure 2 assumes the site, which is highly productive and is site-prepared by broadcast burning, will be planted with spruce seedlings. Assessing three basic stock types, the analysis moves through a series of steps to bring all variables, including stocking targets, probabilities, survival, off-target costs, production potential of the site, seedling costs, planting costs, plantation maintenance and the like to the final denominator of cost per cubic metre of wood produced. Although not always the case, this example demonstrates that the most expensive stock is by far the most cost-effective in terms of future wood production and conceivably a much earlier free-growing plantation.

SUMMARY

Production of nursery stock has changed over the years, mainly at the call of field foresters struggling to establish fully stocked, free-growing stands the first time around. More readily plantable, morphologically and physiologically suitable seedlings have become more commonplace, but the alternatives broaden as we demand site-specific stock. The ultimate decision lies with foresters to make the best choice for the specific situation and to order the best stock type for the job.

TABLE 5. Comparative data, spruce stock size trial, Sx 84107 G

Fort Nelson - Alluvial Site

Stock Class	Description	Replication 1 PSB 313	Replication 2 PSB 313	Replication 3 PSB 313	Averages PSB 313
1 12.5/1.5	Total Ht (cm)	22.5	30.44	25.6	26.18
	Height Increment (cm)	4.83	7.13	8.3	6.75
	Total Caliper (mm)	3.47	4.36	3.64	3.82
	% Survival	67%	67%	67%	67%
2 15.0/1.5	Total Ht (cm)	37.21	28.92	32.04	31.06
	Height Increment (cm)	8.71	6.08	11.25	8.68
	Total Caliper (mm)	4.29	4.27	4.92	4.49
	% Survival	93%	87%	93%	91%
3 15.0/2.0	Total Ht (cm)	28.59	28.5	32.0	29.70
	Height Increment (cm)	6.42	5.33	10.21	7.32
	Total Caliper (mm)	3.88	4.63	5.11	4.54
	% Survival	80%	67%	93%	80%
4 15.0/2.5	Total Ht (cm)	31.39	26.42	33.32	30.38
	Height Increment (cm)	7.93	5.25	10.18	7.79
	Total Caliper (mm)	4.76	4.4	4.67	4.61
	% Survival	100%	87%	100%	96%
5 18.0/2.0	Total Ht (cm)	29.88	29.57	32.9	30.78
	Height Increment (cm)	7.62	6.39	9.05	7.69
	Total Caliper (mm)	4.56	4.31	4.67	4.51
	% Survival	87%	93%	67%	82%
6 18.0/2.5	Total Ht (cm)	36.36	35.35	37.9	36.54
	Height Increment (cm)	10.29	9.12	11.41	10.27
	Total Caliper (mm)	5.29	5.17	5.48	5.31
	% Survival	93%	93%	73%	86%
7 18.0/3.0	Total Ht (cm)	34.71	35.3	38.07	36.03
	Height Increment (cm)	9.0	7.43	10.43	8.95
	Total Caliper (mm)	5.47	4.6	6.11	5.39
	% Survival	100%	100%	100%	100%
8 22.0/2.5	Total Height (cm)	37.15	33.5	35.83	35.49
	Height Increment (cm)	10.12	7.08	8.33	8.51
	Total Caliper (mm)	5.48	4.43	4.77	4.89
	% Survival	87%	93%	100%	93%
9 22.0/3.0	Total Ht (cm)	34.85	35.31	42.18	37.45
	Height Increment (cm)	6.58	5.54	12.04	8.05
	Total Caliper (mm)	5.22	5.11	5.8	5.38
	% Survival	87%	93%	100%	93%
10 22.0/3.5	Total Ht (cm)	40.6	38.92	41.7	40.41
	Height Increment (cm)	9.4	8.81	9.79	9.33
	Total Caliper (mm)	5.79	6.48	5.53	5.93
	% Survival	100%	100%	93%	98%
11 25.0/3.0	Total Ht (cm)	40.92	45.85	42.1	42.96
	Height Increment (cm)	11.19	7.88	9.97	9.68
	Total Caliper (mm)	6.06	6.25	6.86	6.39
	% Survival	87%	93%	100%	93%
12 25.0/3.5	Total Ht (cm)	40.13	41.47	45.21	42.27
	Height Increment (cm)	9.47	7.77	10.43	9.22
	Total Caliper (mm)	5.85	6.13	6.31	6.10
	% Survival	100%	100%	93%	98%

* - denotes no data.

TABLE 6. Comparative data, spruce stock size trial, Sx 84107 G

Fort Nelson - Upland

Stock Class	Description	Replication 1 PSB 313	Replication 2 PSB 313	Replication 3 PSB 313	Averages PSB 313
1 12.5/1.5	Total Ht (cm)	24.43	25.36	19.71	23.17
	Height Increment (cm)	6.76	9.18	4.58	6.84
	Total Caliper (mm)	4.25	4.15	3.6	4.0
	% Survival	100%	73%	80%	84%
2 15.0/1.5	Total Ht (cm)	26.64	26.97	27.6	26.40
	Height Increment (cm)	6.54	9.27	8.15	7.99
	Total Caliper (mm)	4.36	4.67	4.32	4.84
	% Survival	80%	100%	73%	84%
3 15.0/2.5	Total Ht (cm)	27.08	28.31	25.64	27.01
	Height Increment (cm)	5.96	9.31	8.43	7.9
	Total Caliper (mm)	4.7	4.46	4.54	4.57
	% Survival	80%	87%	93%	87%
4 15.0/2.5	Total Ht (cm)	30.73	28.42	26.36	28.50
	Height Increment (cm)	8.80	6.05	5.14	6.65
	Total Caliper (mm)	4.71	4.02	4.22	4.32
	% Survival	93%	87%	93%	91%
5 18.0/2.0	Total Ht (cm)	29.7	30.83	28.4	29.64
	Height Increment (cm)	8.43	7.3	6.4	7.38
	Total Caliper (mm)	4.64	4.07	4.42	4.38
	% Survival	93%	100%	100%	98%
6 18.0/2.5	Total Ht (cm)	35.56	32.0	30.75	32.79
	Height Increment (cm)	9.63	7.12	5.42	7.39
	Total Caliper (mm)	5.78	4.93	4.09	4.93
	% Survival	100%	87%	80%	89%
7 18.0/3.0	Total Ht (cm)	34.06	33.63	33.93	33.87
	Height Increment (cm)	8.17	6.75	7.21	7.38
	Total Caliper (mm)	5.71	5.1	5.26	5.36
	% Survival	100%	93%	93%	95%
8 22.0/2.5	Total Height (cm)	33.3	31.21	32.0	32.17
	Height Increment (cm)	6.67	6.25	7.57	6.83
	Total Caliper (mm)	5.09	4.83	4.79	4.90
	% Survival	87%	80%	93%	87%
9 22.0/3.0	Total Ht (cm)	36.76	37.29	36.7	36.92
	Height Increment (cm)	7.17	9.18	8.7	8.35
	Total Caliper (mm)	6.0	6.09	5.71	5.93
	% Survival	100%	100%	100%	100%
10 22.0/3.5	Total Ht (cm)	38.07	37.35	42.43	39.28
	Height Increment (cm)	6.43	5.58	7.73	6.58
	Total Caliper (mm)	5.7	5.72	5.87	5.76
	% Survival	100%	100%	100%	100%
11 25.0/3.0	Total Ht (cm)	39.40	39.25	37.87	38.84
	Height Increment (cm)	7.43	8.90	8.63	8.32
	Total Caliper (mm)	6.13	6.97	6.21	6.44
	% Survival	100%	93%	100%	88%
12 25.0/3.5	Total Ht (cm)	45.90	41.80	46.67	44.79
	Height Increment (cm)	8.63	8.0	10.7	9.11
	Total Caliper (mm)	6.87	5.66	6.94	6.49
	% Survival	100%	87%	100%	96%

* - denotes no data.

TABLE 7. Percent survival by caliper and height class (from Tables 5 and 6)

Caliper Class mm	Percent Survival	Height Class cm	Percent Survival
1.5	81.5	12.5	75.5
2.0	86.7	15.0	88.2
2.5	90.3	18.0	91.6
3.0	94.8	22.0	95.6
3.5	98.0	25.0	93.8

TYPICAL BRUSH PRONE SITE

ALTERNATIVE #1	ALTERNATIVE #2	ALTERNATIVE #3
BR 2+0	PSB. 2H	PSB 415

PROJECT		STOCKING TARGETS					SURVIVAL		PLANT		OFF-TARGET COSTS				
REGION	G	N ₁	N _U	N _L	$\frac{N_U}{N_L}$	$\frac{N_U}{N_1}$	S	σ	d	N _p	A _U	A _L	B _U	B _L	B
DISTRICT	02														
EXPLANING	07														
NUMBER	P02-01														
DATE	1982														
NAME	MCGREG														

#	PRODUCTION POTENTIAL OF SITE							SEEDLING COSTS				PLANTATION COSTS					
	N _c	H	D	V	W	R	M	C ₁	C ₂	C ₃	C	P	F	Q	T	J	K
1	500	28	50	2.0	1000	100	9.5	12.0	200	300	62	1658	250	3875	2045	2.05	2153
2	450	30	55	2.5	1100	95	10.5	16.0	170	300	63	1181	250	3108	4918	1.36	1421
3	400	35	60	3.3	1300	90	12.0	20.0	230	0	43	645	250	2559	900	0.69	751

STOCKING TARGETS		OFF-TARGET COSTS	
N ₁	- Stocking target (number of successfully established seedlings per hectare).	A _U	- Probability of exceeding N _U .
N _U	- Upper limit of stocking.	A _L	- Probability of not meeting N _L .
N _L	- Lower limit of stocking.	B _U	- Cost incurred if the upper limit of stocking is exceeded (thinning, loss of quality, ...).
N _p	- Number of seedlings to be planted per hectare.	B _L	- Cost incurred if the lower limit of stocking is not met (replanting, loss of production, ...).
n _U	- Percentage by which upper limit exceeds the desired stocking: $n_U = 100(N_U/N_1 - 1)$.	B	- Expected cost of being outside the specified stocking limits: $(B = A_U B_U + A_L B_L)$.
n _L	- Percentage by which lower limit falls short of the desired stocking: $n_L = 100(1 - N_L/N_1)$.		
SURVIVAL		SEEDLING & PLANTATION COSTS	
S	- Average percent survival of seedlings.	C ₁	- Nursery cost per seedling including all production costs (seeding, tending, containers, lifting, packaging, land-rent, overhead, ...).
σ	- Standard deviation of survival (%).	C ₂	- Planting cost per seedling including all field-related costs (planting, transportation, ...).
d	- Dispersion coefficient ($d = \sigma/S$).	C ₃	- Extra cost (eg. special treatment) per seedling.
PRODUCTION POTENTIAL OF SITE		C	- Cost per planted seedling: $(C = C_1 + C_2 + C_3)$.
N _c	- Number of crop trees to be harvested per hectare.	P	- Planting cost per hectare.
H	- Height of crop trees (metres).	F	- Site preparation costs per hectare (burning, scarifying, access, establishment period tending, ...).
D	- Diameter of crop trees (centimetres at breast height).	Q	- Non-planting costs per hectare including site preparation and failure to be within specified stocking limits: $(Q = F + B)$.
V	- Volume of wood per mature tree (cubic metres, average for all species).	T	- Total planting project cost per hectare.
W	- Wood production (cubic metres per hectare).	J	- Present investment (cost) required to obtain one cubic metre of wood at rotation.
R	- Rotation period (years to maturity).	K	- Present investment (cost) required to establish one cubic metre of mean annual increment.
M	- Mean annual increment (cubic metres of wood per hectare per year).		

FIGURE 2. Calculation of cost per cubic metre of wood produced on a highly productive site prepared by broadcast burning planted to spruce seedlings. Three basic stock types are compared.

Ecophysiology: Post-planting Physiological Results and Their Implications for Growing Spruce

by
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In 1983, the Ministry of Forests Research Branch initiated experimental project 966, which focuses on the post-planting ecophysiology of interior spruce, both white spruce (*Picea glauca* (Moench) Voss), and its naturally occurring hybrid, hybrid white spruce (*Picea glauca* x *P. engelmannii*). This focus reflects a concern for interior spruce field survival and growth performance. The ecophysiological framework recognizes the need to study nursery stock physiological attributes in the ecological context of the planting site. E.P. 966 is directed toward identifying factors which may limit survival and growth of white spruce seedlings, and how these limitations may be reduced with a mounding site treatment.

The research site is in the Prince George Forest Region. It is located in the Very Wet Rocky Mountain Sub-Boreal Spruce subzone Devil's Club - Oak Fern - Devil's Club subassociation (SBSI/01.2); moisture regime is subhygric and nutrient regime is permesotrophic. The site, at 1100 m on a northeast-facing slope of the Bowron River Valley, developed extensive herb, shrub and fern communities after harvesting. Fall burning windows in the area are short and inconsistent, and chemical vegetation control is largely untried. Weather records indicate that the area has a 30% chance of spring frost on 16 June and a 10% chance of fall frost by 8 August.

The area was logged in the winter of 1982. In August 1983, the site was patch scarified. Five microsite treatments were carried out: control, inverted organic mat, and three levels of mineral mounding. Figure 1 shows the three microsite treatments selected for intensive study and reported on here. The microsites were planted on 30 May - 1 June 1984 with S.L. 4097, interior spruce 2+1 bareroot stock.

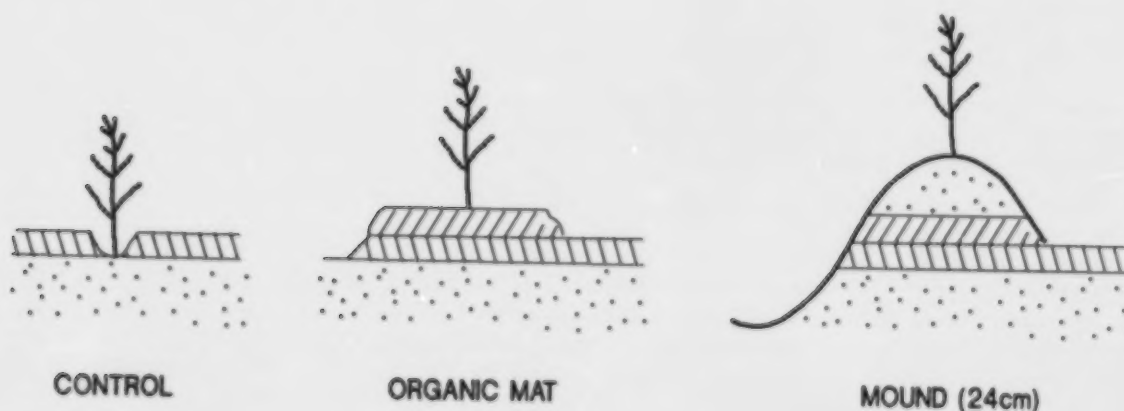


FIGURE 1. Schematic representation of the three site preparation treatments.

A main requirement for seedling survival after planting is the rapid establishment of extensive contact of the roots with the soil. Root growth capacity of the stock used was high at the time of planting. Highest field root growth occurred between six and 47 days after planting, and microsite preparation significantly influenced root growth in the first month after planting. Doubling of soil temperature in the root zone, due to mounding, appeared to be the primary factor.

Maintenance of a favourable seedling water potential (xylem pressure potential (XPP)) is essential to permit normal functioning of the complex physiological and biochemical processes needed for growth. Water potential equilibration between the seedling and soil is never achieved. In the spring and early summer, XPP decreased to a value of -16 - -17 bar within two hours after sunrise. On a clear day, XPP remained at this value for much of the day. Maximum midday XPP on a very wet, rainy day was -10 - -12 bar. White spruce adjusted cell turgor balance downward in the late summer and early fall allowing the daytime XPP to decrease to about -21 bar.

White spruce stomata responded very quickly to relative humidity (RH) and temperature changes when critical values were reached. Rapid stomatal closure occurred when the combination of RH and temperature produced a vapour pressure deficit (vpd) of greater than 1.5 kPa. Daily maximum vpd's greater than 1.5 kPa occurred on 30-40% of the days from June to August. Stomatal conductance varied with temperature depending on the year. In the planting year, conductance became minimal at 25°C, whereas by the second year the critical temperature for stomatal closure had risen to near 30°C, suggesting some seedling adjustment to the field environment. This was probably the result of a larger root system being better able to supply water to the seedlings to replace transpirational loss, and thus maintain a favourable leaf water status. There is also a positive relationship between stomatal conductance and light intensity.

In the planting year, greatest water loss took place at midday, coinciding with highest daily temperature and photosynthetic rate. In the second year, transpiration rate was lowest at first light, increased rapidly, then declined throughout the day. Different weather conditions and seedling adjustment to the environment were probably responsible for this difference.

Photosynthesis had an average diurnal rate of just over 4.0 mg CO₂ dm⁻² h⁻¹ from early June through the end of September. Apparent photosynthesis was positive between 5° and 28°C and maximal at 22°C. The photosynthetic process became light saturated at just over 600 μE m⁻² s⁻¹. Photosynthetic rate was highest when stomatal conductance was greater than 0.2 cm s⁻¹, and there was little change to 0.1 cm s⁻¹, but thereafter photosynthesis rapidly decreased. At conductances below 0.04 cm s⁻¹ stomates were closed and photosynthesis was essentially zero.

Chlorophyll is the light-absorbing green pigment required for photosynthesis. After two weeks, seedlings planted in the open (no shade) lost up to 40% of this pigment, probably through solarization (photochemical destruction by solar radiation). This may have adversely affected photosynthesis. Changes in light quality due to shading by other plants may also have affected the seedlings.

Clearly the poorest field condition into which to plant white spruce is a dry, open site, or one where other vegetation is excessive. Some implications on this subject, and potential benefits of summer planting, from an ecophysiological point of view, are discussed.

Physiological evidence collected in this study suggests that the condition commonly called "growth check" in white spruce may actually be a result of an inelastic physiological drought-avoidance mechanism. White spruce apparently maintains a daytime XPP of approximately -16 bar in late spring and early summer. If water uptake by the roots cannot replace transpirational loss, and maintain this water potential, the stomates close, resulting in cessation of photosynthesis within 20 minutes. Once stomates are closed they do not reopen that day. The amount of time stomates open the next day depends on the amount of water recharged during the night. If predawn XPP is below -10 bar, recharge is low and the period of stomatal opening may be very short. Cell osmotic adjustment to about -21 bar allows physiological functioning during summer drying and is most likely a natural result of frost hardiness and dormancy induction.

If the drought-avoidance hypothesis is correct, "growth check" can never be, nor indeed because of its survival value, should never be cured. However, "check" may be minimized by providing favourable microsite conditions. The most important of these include:

1. ensuring soil temperature above 10°C for much of the growing season to aid root growth;
2. maintaining the vpd below 1.5 kPa;
3. reducing the light intensity by about 30-35%, yet ensuring an intensity above 600 $\mu\text{E m}^{-2} \text{s}^{-1}$ for the longest daily duration possible; and
4. ensuring daytime air temperature above 15° but below 30°C.

In practical terms, only (1) and (3) can be achieved by silvicultural treatment such as mounding and brushing and weeding.

Analysis of Summer Planting for Backlog Sites: Progress Report

by
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Summer planting has been investigated in the boreal and sub-boreal regions of Canada (Burgar and Lyon 1969; Crossley 1956; Decie 1962; Revel and Coates 1976); all researchers demonstrated the feasibility of summer planting of bareroot white spruce seedlings. Revel and Coates (1976) studied summer planting at McLeod Lake under conditions highly representative of mesic to subhygric sites in the Sub-Boreal Spruce biogeoclimatic zone of British Columbia. Seedlings (cold-stored and freshly lifted) were planted at two-week intervals throughout the summers of 1968, 1969 and 1970 and were assessed for three growing seasons after each planting. Survival remained above 75% even under the driest, hottest planting conditions which infrequently occur under sub-boreal summer weather conditions. Summer weather in the sub-boreal is generally cloudy with showers and high humidity (Table 1).

As the planting program in the Prince George Forest Region expanded to more than 50 million seedlings per year, it was obvious that a longer planting season was required. Therefore, in 1982, following a decision by Al Todd, then Silviculture Officer, more than 1 million white spruce seedlings were planted using the recommendations of Revel and Coates (1976: EP668). Successful early results prompted the Region to continue and expand this operational summer planting. Bareroot stock types were largely replaced with plugs, and results were equally good.

Each year persons in charge of the summer planting program were canvassed, and they reported excellent survival and growth "as good or better than spring planting." It was concluded, however, that a representative number of summer plantations should be formally monitored. The following is a progress report on SX84-114G. One more remeasurement of this SX trial (1986 plantation) is necessary before the final report is completed.

REPORT ON SX84-114G

During each of the years 1984, 1985 and 1986, five representative summer planting projects were selected for monitoring. These plantations sampled a variety of biogeoclimatic zones and subzones in mesic and subhygric associations, as well as a variety of stock types and originating nurseries. They were all operationally planted in mid-July to mid-August.

No attempt was made to study stock types, nurseries or seedlots, and plantations were considered to be a representative cross-section of the annual summer planting program.

Staked plots were located at random in each plantation. Four sub-plots of 25 staked seedlings each were measured annually for three growing seasons. Survival, total height and leader length were measured (see Tables 2, 3 & 4).

Survival for all plantations after three growing seasons averaged 79%. Unacceptable survival occurred at Catfish Creek in 1984, which was not related to the time of planting. The site had deep duff suspended over an open water table, combined with losses to root collar weevils.

Growing season precipitation for 1984, 1985 and 1986 is shown in Table 1.

Generally acceptable to good root egress occurred in most of the plantations studied. In July and early August on mesic and subhygric sites soil temperatures were between 8-12°C, which promoted active root growth. However, by late August, particularly on subhygric sites, temperatures were in the 5-7°C range, which may be marginal or may cause cessation for root egress.

TABLE 1. Results of 1984 summer planting, SX84-114G

Plot	Location	Stock Type	Height at Planting (cm)	Height (cm)	Fall 1985 Leader (cm)	Survival (%)	Height (cm)	Fall 1986 Leader (cm)	Survival (%)
1	Missinchinka SBSj2	PSB 211 +1	25.5	30.9	5.4	99	33.4	1.4	94
2	Tumbler Ridge BWBSd	2+1	21.9	24.0	2.1	86	25.2	1.7	78
3	Wonowon BWBS	PSB 211 +2	28.1	29.6	3.1	88	29.6	1.5	68
4	Pinchi Lake SBSk3	PSB 211 (2+0)	22.2	28.8	6.6	74	34.4	4.4	70
5	Catfish Cr. ¹ ICH	PSB 211	24.4	28.4	4.0	57	29.7	2.7	49
Average			24.4	28.7	4.2	81	30.5	2.3	71

¹ Deep duff suspended above an open water table.

TABLE 2. Results of 1985 summer planting, SX84-114G

Plot	Location	Stock Type	Height at Planting (cm)	Height (cm)	Fall 1986 Leader (cm)	Survival (%)	Height (cm)	Fall 1987 Leader (cm)	Survival (%)
1	Osborn BWBS	PSB 313 (2+0)	19.1	25.8	7.1	96	29.5	4.5	92
2	Stephen Lake SBSj1	PSB 313 (2+0)	24.8	31.0	6.7	71	38.2	7.4	70
3	Gagnon Cr. SBSj2	PSB 313 (1+0)	17.7	24.1	9.0	93	31.0	8.9	92
4	McKale Rd. ICHj	PSB 313 (2+0)	30.5	31.0	5.3	73	33.6	2.8	73
5	Bill's Cr. SBSj1	1.5 + 1.5	22.2	27.4	9.8	95	28.7	2.0	85
Average			22.8	27.8	7.6	86	32.2	5.1	82

TABLE 3. Results of 1986 summer planting, SX84-114G

Plot	Location	Stock Type	Height at Planting (cm)	Height (cm)	Fall 1987 Leader (cm)	Survival (%)	Height (cm)	Fall 1988 Leader (cm)	Survival (%)
1	Buick Cr. BWBS	PSB 313 (2+0)	19.7	29.3	10.1	97			
2	Ptarmigan Cr. ICHk	1.5 + 1.5	20.1	26.8	7.0	87			
3	Little Field Cr. SBSj1	PSB 313 (2+0)	26.5	33.1	8.4	92			
4	Tannizul (TFL42) SBSk3	1.5 + 1.5	24.6	24.8	4.3	70			
5	Summit Lake SBSse2	PSB 313 (2+0)	18.1	22.1	6.8	75			
Average			21.8	27.2	7.3	84			

TABLE 4. Results of summer planting, SX84-114G

Survival %		
Planted Summer 1984	Mean survival after 2½ seasons	71%
Planted Summer 1985	Mean survival after 2½ seasons	82%
Planted Summer 1986	Mean survival after 1½ seasons	84%
All years (1984, 1985, 1986) 79% - Range 49% - 97%		

Since root egress to establish a "water chain" and to anchor seedlings to reduce frost heaving is a fundamental factor in successful summer planting, planting is recommended before mid-August in the boreal and sub-boreal zones. This is very significant on subhygric sites and sites that have been mechanically prepared to expose mineral soil. On sites prepared by broadcast burning where more than 2 cm of insulating duff are present, frost heaving is not a significant problem.

RECOMMENDATIONS

Based on current knowledge the following guidelines should be used:

1. summer planting should be restricted to mesic to subhygric moisture regimes (preferably broadcast burned);
2. planting after mechanical site preparation which has exposed bare mineral soil should be avoided due to the high risk of frost heaving of container seedlings, particularly after 31 July and/or in subhygric sites;
3. the maximum period between extraction (or lifting) and planting should remain at three days. Where this time period is not maintained, seedlings should be heeled in or placed upright in open cartons and watered;
4. a cautious and carefully monitored program of planting lodgepole pine should be initiated;
5. RGC's (root growth capacity) should be measured periodically for all seedlots at the time of shipment from the nursery and correlated with root egress in the forest soil;
6. soil temperatures in the rooting zone should be measured on a daily basis and correlated with root egress on all summer planting projects. Temperatures below 8°C will not promote rapid root egress; and
7. seedlots should be designated for summer planting at time of sowing request and should, where possible, be grown within the region. These seedlots should be subjected to special cultural regimes to condition them for summer planting, but they should not be severely stressed.

SUMMER PLANTING WITH SPECIAL REFERENCE TO BACKLOG SITES

Experience has demonstrated the high success of planting on well-executed prescribed burns. The results of summer planting to date also substantiate this fact. Results are not as predictable or consistent after mechanical site preparation. Frost heaving, "baking," flooding, etc., are more common than under prescribed burn conditions. Since a major proportion of backlog site preparation must be done mechanically, special precautions will be necessary.

Summer planting on mechanically prepared backlog sites should be restricted to associations which are moderately well to well drained (mesic) to reduce frost heaving, and to warmer soils. Clay loams and silt loams should be planted in the spring to allow a longer period for root establishment (or if summer planted, not after 31 July).

In general, summer planting should be directed to good prescribed burns and spring planting to good prescribed burns and mechanically treated sites.

The History, Development and Future of Mechanical Planting in British Columbia

by

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Mechanized planting began in British Columbia early in the 1950s, when Jack Walters developed a hand-held planting gun and complementary hardwalled container. The combination facilitated a one-step planting process, whereby the containers made their own hole as they were thrust into the ground (Lawyer 1978). The original styrene container was bullet shaped and constructed with walls weakened by a narrow longitudinal slit. Preliminary field tests were promising, achieving planting rates as high as 1500 seedlings per hour (Walters 1961). However, subsequent field examination indicated that the bullet restricted optimum root growth.

Throughout the 1960s and early 1970s research was undertaken to produce a bullet which could be efficiently grown in the nursery and cheaply outplanted, yet still maintain a high level of biological acceptability. A number of bullet designs and various construction materials were utilized. The feasibility of biodegradable bullets was also investigated (Griffin 1971; Walters 1974a).

From 1968 to 1972 over one million round bullets were planted by the Forest Service and industry (Jones 1979). On the basis of early experience with "plugs" raised in Walters's bullets, the styroblock reforestation system was developed (Arnott 1971; Bamford 1974). In due course, the round bullet was replaced by the square "Walters Bullet," a plastic bullet consisting of four separate sections with apertures to accommodate root egress (Walters 1974b).

In 1985, International Forestech Systems Ltd. began development of a biodegradable container similar in size and shape to the segmented plastic container. The cartridges, known as xylons, were constructed of wood wastes and organic binders. Tests initiated in 1986 proved unsuccessful due to premature expansion of xylons in the nursery.

Mechanical planting systems were developed concurrently to dispense bullets more efficiently. Throughout the 1960s research concentrated on improving hand-held planting guns.

In the early 1970s Jack Walters, in cooperation with the provincial and federal governments, became involved in the development of mechanical planting machines. Development led to the "Walters Reforestation Planter," a three-armed automatic planter which was projected to have a planting capability of 20 000 seedlings per eight-hour shift (Walters 1979). The prototype was tested in the Quesnel Forest District in 1978. Mechanical unreliability resulted in termination of the project (Brewis 1979).

Subsequently, federal funding was granted to Alan Moss and Associates to develop a commercial model of the Reforestation Planter. This led to the development of the Silvaplanner PBII spot planter. This planter was equipped with a steel probe that forced its way into the ground prior to the insertion of the cartridge. If the probe struck a rock or met excessive ground resistance the planting attempt was aborted and a second attempt was made about a foot further along. Further development of the hardwall planter was discontinued in 1982 due to concern over the acceptability of the plastic container.

In the mid-1970s additional research was initiated by the Forest Service to investigate the feasibility of mechanically planting bareroot and softwall (styroblock) plug seedlings.

At this time, sites in the Mackenzie, Vanderhoof and Quesnel Forest Districts were operationally planted with the Cazes and Heppner (C&H) Tree Planter. The C&H planter was towed behind a crawler tractor equipped with a Cazes and Heppner Reforestation Plow which removed debris and created a furrow for the planter. When planting with the C&H Planter an individual sits in the planter and places seedlings directly into a continuous slit which is created by the coulter wheel of the planter. The planting slit is then closed by two packing wheels.

The final data from these trials are shown in Table 1. In general, survival and growth were influenced more by microsite position than by planting method (Butt and Cousens 1988). Seedlings planted mechanically were situated in the bottom of a continuous furrow while hand-planted trees were planted on the adjacent raised berm. In drier, coarse-textured soils, results for mechanical planting were superior due to the increase in moisture associated with the planting furrow. In contrast, on fine-textured, wetter soils, results for hand planting were superior due to the increased drainage and temperature associated with a raised microsite.

TABLE 1. Mechanical planting trials: 1987 assessment. All sites were broadcast burned prior to planting (Butt and Cousens 1988).

Forest District	Stock Type	Planting Date	Soil Texture	Moisture	Average Height (cm)		Survival (%)	
					Hand Planted	Machine Planted	Hand Planted	Machine Planted
Vanderhoof	PI PSB 211 1+0	Spring 1977	Silty Clay	Subhygric	266	233	79	67
Vanderhoof	PI PSB 211 1+0	Spring 1977	Gravelly Sandy Loam	Submesic	340	376	not available	
Quesnel	S BR 2+0	Spring 1977	Gravelly Sandy Clay Loam	Mesic	163	145	95.0	95.7
Mackenzie	PI PSB 211 1+0	Spring 1975	Loamy Sand	Submesic to Subxeric	327	450	not available	

Mechanically planted seedlings showed an increase in basal sweep and, in some cases, tended to have a more asymmetrical root system with roots initially oriented along the planting trench. Tree form, however, was generally not considered a significant problem (Butt and Cousens 1988).

In 1987, three types of mechanical planting machines were tested in British Columbia: the C&H planter; the Quickwood Planter; and the C&G planter. Only the C&G planter met operational planting standards. Table 2 summarizes operational planting quality and productivity for the C&H planter. Productivity values indicate that on flat, windrowed sites, mechanical planting costs would compare favourably with the cost of hand planting.

TABLE 2. Cazes and Heppner mechanical planter - 1987 productivity and planting quality

Forest District	Total Trees Planted (In 000's)	Productivity (Trees/Hr)	Stock Type	Planting Quality (w/o 5% tolerance)
Williams Lake	32	898	PI PSB 211	84%*
Dawson Creek	50.2	812	S PSB 313	91%
Ft. St. John	13.4	746	S PSB 313	not available
P. George W.	11.2	564	S PSB 415	not available

*Quality reflects inexperienced crew, difficult soil conditions, and small stock.

First season growth and survival data were also recorded at Dawson Creek. Results from this trial are shown in Table 3. The increased volume associated with mechanical planting is attributable to warmer soil. While initial results are promising, indicating performance for machine-planted seedlings slightly superior to hand planting, it must be noted that the mechanically planted trees are situated on exposed mineral soil and hence are more susceptible to frost heaving. This may affect the second-year growth and survival of mechanically planted trees.

TABLE 3. First growing season assessment of mechanical planting - Dawson Creek Forest District (1987). Stock is PSB 313 2-0 (Maxwell 1988)

	Hand Planted	Machine Planted
Survival (%)	93.3	94
Root Collar Diameter (mm)	4.76	5.24
Total Height (cm)	24.4	27.1
Increment (cm)	7.39	10.72
Tree Volume (cm ³)	1.477	1.948

In the near future both operational mechanical planting and research and development will continue in British Columbia. In 1988 a modified C&H planter will be used operationally in the Invermere and Mackenzie Forest Districts. A mechanical spot planter, capable of planting styroblock-type plugs, has been designed by Loentech Engineering (distribution and manufacturing rights are held by International Forestech Systems). A pre-production model of this planter will be tested during the 1988 field season. The federal government will continue to work on the development of a planting bullet designed to meet both operational and biological standards. Federal funding has also been allocated to further the development of the SPII hardwalled (bullet) planter.

The long-term future of mechanical planting in B.C. is difficult to predict. The extent to which mechanical planting is adopted will be determined by the desire of the forest community to adopt it, the success of new planting machines and the cost of hand planting.

Silvicultural Responses in the Boreal White and Black Spruce Zone

by
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Research undertaken to support the Ministry of Forests program of hardwood stand conversion in the Peace River area is producing information pertinent to white spruce silviculture in the Boreal White and Black Spruce (BWBS) zone. This report presents observations of vegetation and softwood crop responses to silvicultural treatments, and discusses factors which may affect the performance of white spruce.

RESPONSES OF COMPETING VEGETATION

Of competitors to white spruce, bluejoint reed grass (*Calamagrostis canadensis*) and trembling aspen (*Populus tremuloides*) are among the most aggressive. The effect of site preparation on the growth and spread of reed grass was observed for four levels of soil manipulation. Simple blade scarification resulted in patchy scalping of the soil surface and uprooting of reed grass sod and surface organic material. A modest level of soil mixing was achieved with the use of a tandem cultivating disc. This treatment provided good control of reed grass during the first growing season. Beginning in the second year, however, the improved soil structure and temperature regime created by discing encouraged the rapid spread of the species. Similar responses may be expected from other disc-like equipment, such as the bedding plow.

Complete soil inversion with an agricultural, moldboard plow provided the best control of reed grass during the first two years after treatment. However, plowing promoted higher soil temperatures in the root zone over the two-year period, and by the third year reed grass encroachment of plowed soil had substantially increased.

Reed grass abundance on the undisturbed control treatment exhibited an inverse relationship with the density of aspen suckers.

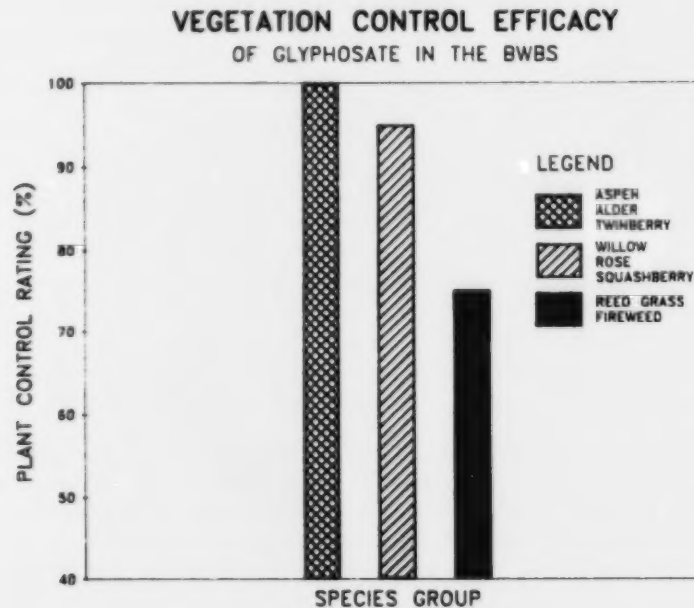


FIGURE 1. Vegetation control efficacy of glyphosate on three plant groups in the BWBSc1 subzone.

Reed grass is operationally controlled in the Peace by glyphosate applications. Evaluation of glyphosate efficacy suggests only an intermediate level of control (see Figure 1). Glyphosate applications in older aspen/grass communities indicate grass control efficacy declines as aspen dominance and canopy interception increases. Control of mixed aspen/reed grass communities with glyphosate should therefore be carried out before aspen canopy development is advanced in order to prevent a prompt reinvasion of reed grass.

The effectiveness of reed grass control with hexazinone has also been studied in the Peace River. A key factor affecting hexazinone efficacy may be the degree of soil disturbance and application timing. Excellent results were achieved in the Peace River area with concentrated spot dispersions applied immediately prior to a low-disturbance aspen stand clearing.

Blade scarification displaces a substantial amount of trembling aspen root propagules, reducing suckering by as much as 50%. Further reductions in aspen density are achieved by subsequent disc or plow cultivation.

Glyphosate proved extremely effective at controlling well-developed sucker shoots (see Figure 1), although small shoots may survive applications. It is therefore recommended that glyphosate not be applied until the second growing season following site disturbance to allow time for small suckers to reach sufficient size for adequate glyphosate absorption.

Testing of liquid hexazinone, applied in a broadcast spray, provided only intermediate control of aspen suckers. Better control was achieved with concentrated spot distributions, applied shortly before low-disturbance clearing treatments.

Absolute control of seral reed grass and aspen communities is not possible with single-pass mechanical and chemical treatments. At best, two years of reduced competition is afforded by such treatments. It is therefore crucial that seedling vigour be adequate to capture the temporary increase in site resources and to improve its competitive position. An effective scarification treatment, followed by prompt brushing and weeding, should ensure plantation success.

RESPONSE OF WHITE SPRUCE TO SILVICULTURAL TREATMENT

The effect of site preparation method on seedling diameter growth over a three-year period is illustrated in Figure 2. Seedling height increment during the third growing season followed a similar trend. Diameter response to treatment was also detected during the second growing season, but not during the first (Herring and Letchford 1987).

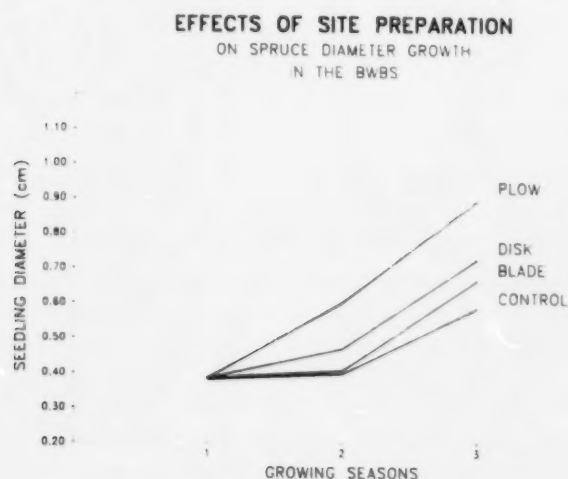


FIGURE 2. Site treatment main effects on seedling mean diameters over three growing seasons in the BWBSc1 subzone. Third season treatment values followed by a letter in common were not different at $p = 0.05$.

An immediate diameter growth response to brushing and weeding during the second growing season was observed for all site preparation treatments. Brushing and weeding resulted in a 30% improvement in seedling diameter growth, whereas height growth was unaffected.

The growth improvements associated with soil cultivation are most likely attributable to treatment effects on vegetation competition levels and soil temperatures. Plow cultivation reduced vegetation cover relative to non-cultivated controls. Height differences of competing vegetation followed a similar trend. Soil temperatures at 5 cm depth were markedly affected by site preparation treatment. Throughout the first growing season, plow cultivation resulted in an increase in mean weekly soil temperature relative to controls. Disc cultivation yielded a 40% increase, while blade scarification was little different from controls. Mean weekly temperatures were reduced by approximately 10% on all site treatments during the second growing season as a result of vegetation redevelopment and soil shading. Figure 3 illustrates the magnitude of treatment differences in diurnal soil temperatures during early July of the second growing season.

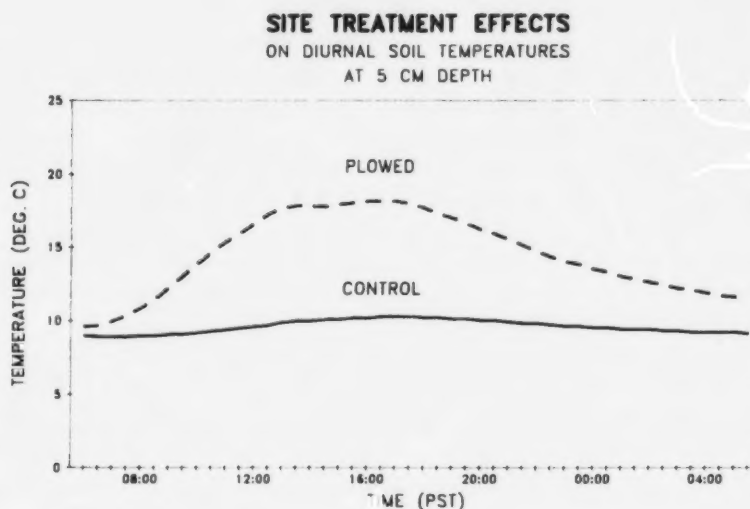


FIGURE 3. Diurnal soil temperature profile, on July 3-4, at 5 cm depth, of a plowed and noncultivated control plot during the second growing season following site preparation.

SEEDLING FACTORS AFFECTING RESPONSE

Seedling morphology and physiological condition at the time of planting determine how promptly the crop establishes and adapts to the site. Speedy establishment assures the seedling a competitive position in capturing site production potential and remaining in a dominant position relative to its competitors.

The quality of the established seedling and the timing of the second-pass silvicultural treatments affect treatment response in a similar manner. Weeding treatments should be carried out at the earliest possible time. Newly planted white spruce seedlings have sustained severe foliage and stem tissue injuries during the first overwinter period in the field. The subsequent growth performance of winter-injured seedlings is greatly reduced. Winter shoot damage has also been linked to reduced root vigour (Colombo and Glerum 1984).

Several planting stock and environmental characteristics are associated with injury. These include time of planting, first-year growth performance of planting stock and degree of environmental exposure of stock over winter. First-year winter injury is commonly sustained by white spruce stock planted during the spring.

The incidence of winter injury is reduced where the seedling remains under snow cover during winter. Reduced injury is most frequent where seedlings are located in the lee of a terrain feature.

Seedling injury is thought to occur late in the first winter. Seedlings which are uninjured during the first winter are not injured during subsequent winters. Similarly, seedlings which sustain first winter injury are not injured subsequently.

The cause of winter seedling injury is not yet known. Two theories prevail as to the main source of injury: frost drought, and freezing injury. Evidence from the Peace River area favours the latter theory. Of the factors responsible for inadequate cold hardiness development, first-year seedling phenology and growth rhythm may provide clues. First-year, spring-planted spruce seedlings maintain active shoot growth up to three to four weeks later in the summer than older seedlings. Prolonged first-year shoot growth has been attributed to a temporary, nursery related growth rhythm (Heide 1974).

In the Peace River area, there may be a greater tendency for free growth than at more southerly latitudes. While this capacity increases the height growth performance of first-year seedlings, there may be risks. Active shoot growth must cease before development of winter hardiness can begin (Glerum 1985), and budset must take place well before fall frosts (Pollard 1974; Campbell and Sorenson 1973). Late development of either may adversely affect cold tolerance (Jonsson *et al.* 1986; Colombo 1984). Changes or delays in the normal growth rhythm may also affect the morphology of seedling tissues (Tranquillini 1982).

The need for well-adapted growing stock for the demanding environmental conditions of the BWBS makes further study necessary. Seedling production must maximize the adaptability of the seedling to its post-planting environment. The existing morphological basis for evaluating seedling quality and prescribing appropriate stock types may be inadequate for regenerating sites with a risk of winter injury.

Mechanical Site Preparation in Sweden and Finland

by
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FACTORS AFFECTING TRANSFER OF SITE PREPARATION TECHNOLOGY

Sweden and Finland have a long history of developed reforestation practices. Since their forests are similar to our boreal forests, we should be able to utilize their experience and technology. However, how a site should be reforested is strongly influenced by economic, technical, biological and other constraints.

Economic Constraints

Fennoscandian countries have legislation requiring that forests must not be made non-productive (i.e., insufficiently restocked). Stocking requirements are considerably higher than in B.C.; this may affect motivation for selecting the intensity of treatment. Fennoscandian land tenure is predominantly private ownership, which may affect motivation to increase production. The value of the forest resource (i.e., stumpage) is higher in Fennoscandia. Hence, more funds are available for expensive treatment.

Increasing attention is paid to economic assessment of treatments over time. Narrow assessment criteria such as cost per hectare or machine costs are recognized as poor indicators of treatment value. The difference in treatment costs between a cheap and expensive establishment method is small in relation to the value of the stand over time. Retreatments are very expensive and research indicates that supplementary planting contributes little to a stand's production. Satisfactory results must be obtained with the first treatment. Some agencies are now paying more for better-quality adapted site preparation.

Technical Constraints

Despite stonier soils it may be technically easier to carry out mechanical site preparation in Fennoscandia than in Canada. The most obvious and critical component is slash. The Swedes and Finns have very high utilization standards. Managed thinned stands have unmerchantable materials removed before harvest, whereas Canadian slash loadings may be equivalent to final harvest volumes in the north.

Rates of travel with scarification work may be two to five times slower in Fennoscandia than in Canada, affected by relatively stony and shallow soils. The slower speeds and lower rates of productivity may yield better-quality site preparation results and less machine wear.

Fennoscandian social/political systems have more worker benefits, so labour relations and worker motivation are probably better than in Canada. The mechanization infrastructure is well developed and facilitates servicing.

Biological Constraints

Many environmental factors are similar in Fennoscandia to those in Canada, though there are important differences, such as shallower, stonier soils with less variation and fewer fine-texture classes. For the most part, the ecological niches of spruce, pine and broadleaved species are fairly similar.

Extensive biological research has shaped the development of reforestation practices in Fennoscandia, particularly studies concerning the benefits of site preparation and elevated planting. Environmental awareness and public pressure have affected mechanical site preparation practices, mostly in the reduction of "harsher" methods such as plowing.

DEVELOPMENT OF SITE PREPARATION PRACTICES

Artificial reforestation in Fennoscandia really got under way in the 1950s. The initial dominant site preparation method was prescribed burning. This method died out at the end of the 1950s due to limited availability and high cost of labour, insufficient exposure of mineral soil, problems with variable weather, insurance, incidence of *Rhizina* fungus, etc.

Patch scarification had been carried out manually or with horse-drawn implements. A similar principle was first employed behind an agricultural tractor in 1952. The introduction of the skidder in the early 1960s saw the rise of patch scarifiers. Research from the late 1950s had demonstrated good results with patch scarification, but there were mechanical difficulties on rocky terrain, problems with flooding, matting of vegetation and lack of sufficient mineral soil exposure.

Reforestation plows were developed in Finnish Lapland in the mid-1960s. Plowing was important for improving microsite drainage, breaking up inactive humus layers and raising soil temperatures. Since 1967 plowing has been the dominant method in Finnish Lapland where soils are cold and moist, though it has been used throughout Sweden and Finland with good results. Environmental pressure has recently curbed its use.

Disc trenching (or disc plows) also came into use in the mid-1960s. It was thought that freely rotating discs would overcome obstacles with less stress than patch scarification or plowing. Continuous trenches would provide good planter access and a large selection of planting points. Disc trenching has been the dominant site preparation method in Sweden and south and central Finland through the latter 1970s and early 1980s.

The first prototype mounder was introduced in 1976. Interest was aroused in creating elevated microsites such as plowed tilts (or berms) without radical soil disturbance. Mounding had been done in Fennoscandia for about 20 years using the excavated spoils from ditching.

CURRENT TRENDS

Through the 1960s and 1970s Fennoscandian forestry saw an increase in production and mechanization. Large-scale forestry (i.e., large companies in Sweden) dominated, and silvicultural treatments were sometimes relatively harsh. Criticism of harsh treatments along with concern for long-term production have focussed attention on biological processes. This is reflected in a high proportion of physiological studies in regeneration research.

In Sweden, the National Board of Forestry and all the large companies have initiated training programs to increase the biological awareness of field personnel. There is a clear trend toward greater emphasis on the judgement of field staff for making prescriptions in both Sweden and Finland.

Site-adapted site preparation has been discussed since the beginning of the 1980s in Sweden. Closer adaptation of treatments to variation in site conditions should reduce the risk of failure and increase the long-term production of the stand.

Planning units for silvicultural treatments are decreasing in size and may be one-quarter to one hectare with progressive companies. Information systems, including follow-up and assessment, are growing.

Operators are trained to adapt the type or degree of cultivation while driving to accommodate changes in site conditions. Biological knowledge, however, has not caught up with recent advances in machinery. Initially there was interest in developing machines that could do two jobs, such as disc trenching and plowing. Later it was found more attractive to provide treatments with widely varying degrees of cultivation. This was done with adjustments for downward pressure, disc angle, rotation speed (or direction), along with intermittent and continuous options. Presently there is a drive to simplify machine controls. The capability of a machine to provide elevated planting positions along with adjustable alternative treatments are considered important criteria for assessing newer site-preparation implements.

SUMMARY

The application of Fennoscandian site preparation implements in Canada will not be the same as in Sweden or Finland. Such factors as slash loading, finer more variable soil textures, fewer stones, more slopes, lower stocking standards, fewer available funds, shorter-term assessment of treatments, higher rates of productivity, varying familiarity and operator motivation, less extensive testing of new implements and shorter background with site preparation practices all affect the transfer of Fennoscandian technology.

The current Fennoscandian trend toward site-adapted site preparation involves more sophisticated equipment, training and planning. More attention is paid to reducing the risk of failure and increasing stand production.

Hardwood Conversion — How Much is Required?

by
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Hardwood conversion is becoming controversial in the Peace River area. The rehabilitation goal at its peak in the Fort Nelson, Fort St. John and Dawson Creek Forest Districts was in the neighbourhood of 6000 ha annually. Rehabilitation in Dawson Creek was 2000 ha annually, primarily hardwood conversion. Nobody spent much time determining or even caring how much was required because hardwoods were not valued. But the issue of how much was required changed dramatically when new players came on the scene, said that there was a valuable resource out there and built a plant to prove it — Louisiana Pacific's waferboard plant. Forest managers now look rather foolish prescribing Cats on thrifty hardwood stands when someone is right next door harvesting and processing it.

The problem now is not only determining how much hardwood conversion is required: it is hard to justify destroying any amount of a future crop of hardwood (perhaps halfway to rotation age) just to plant conifer. Quite often, we would have to double-treat sites to break up sod layers for plantability and microsite suitability. We would then plant spruce and, dependent upon the competition levels of grass and/or hardwood, prescribe herbicide treatment. Even after these costs were incurred our successes were limited. The cost of establishing a spruce plantation quite often reached in excess of \$1000/ha.

We now know that hardwoods out-perform conifers, they establish at little or no reforestation cost, and they have a much shorter rotation, not only because of growth but because of end-use (pulpwood vs. sawlog). Regardless, it was determined in the Peace TSA Yield Analysis that some 140 000 ha of NSR lands in the Dawson Creek and Fort St. John Forest Districts must be intensively reforested to maintain the softwood Annual Allowable Cut in the long term. My experience has shown that this so-called NSR land is in fact supporting a majority of immature hardwoods.

So back to the question — how much hardwood conversion is required?

First, the not satisfactorily restocked (NSR) and non-commercial brush (NCBr) sites will be reforested. If that is not enough, then conversion may be considered. With only one plant processing hardwoods, both interests could be satisfied quite easily with continued conversion. However, since Louisiana Pacific began production, interest in hardwoods has increased dramatically. Louisiana Pacific wants to expand its operation. Currently, it proposes to start construction in the spring of 1988 of capacity equivalent to 1.6 million m³, or roughly as much as the softwood harvesting in the four sawmills in the Chetwynd and Fort St. John areas.

Other companies such as Fibreco Inc. want to construct a pulpmill for aspen utilization. Recent interest has also been shown in the Fort Nelson area with advertisement of PA 14. It appears that the hardwood industry may even surpass that of the softwood industry in the Peace.

The number of jobs created through harvesting, transportation and the mills may also surpass that of the softwood industry. To illustrate the importance of this new industry, the additional employment resulting from Louisiana Pacific's proposal is 300 jobs in the mills, 615 jobs in harvest and transport, plus 4000 indirect jobs.

As a result of these new factors, hardwood vs. softwood management decisions have become almost political. We have three options:

1. hardwood should be converted to softwood, regardless of the obvious advantages of hardwood management, to protect the sawlog industry;
2. in the next rotation, we can allow the new industry to replace jobs that may be lost in the softwood industry without conversion and manage hardwoods for hardwood; or
3. we can practice mixed wood management in some areas to maximize the productivity of the land base.

I lean to options #2 and #3 — Forest Managers in the softwood industry may have problems with #2, but it certainly would not be the first new industry that replaced old.

As the past has proven, in order to stay in the forest industry one must change with the times as well as the resources available. Recent experience has shown this with the utilization of lodgepole pine and close utilization standards. In Eastern Canada where the forest industry started out logging the large pine trees, once this resource was depleted the mills converted to the manufacture of pulp and paper as well as hardwood manufacturing facilities; obviously, markets dictated the speed of this conversion.

I realize that this last comparison is not completely fair because of the strides made in silviculture to maintain a softwood (sawlog) industry, but can we truthfully foresee waiting 100 years in the Prince George TSA for peeler stock and sawlog timber, or will mills adapt out of necessity to utilize our 40-50-year-old plantations on more of a fibre or biomass utilization standard? Go into today's lumber yard and you will see oriented strandboard, fibreboard, finger-jointed 2 x 4's, waferboard and many other "value added" products. If these products are comparable structurally and in price, there is without doubt a future market for them.

With option #2, Forest Managers could make quick decisions based on the scenario that we should manage pure deciduous stands for deciduous, and pure coniferous for coniferous. And, when dealing with mixed stands, most everyone would welcome a mill that utilizes hardwoods because it not only would make available more softwood for lumber productions but also would save money on site preparation.

In mixed stands the Forest Manager must decide for which species an area is to be managed, a decision which is not as straightforward as in the pure stands. If the choice is hardwoods, in most cases stocking will be achieved naturally. Softwoods will require artificial reforestation, which would probably result in many stands in mixed species. Since, even on softwood management areas, hardwoods can never be eliminated, just reduced to tolerable levels, the Forest Manager must deal with different growth patterns and possibly different uses of species. Two-pass logging may also be required to protect the understory if stands continue to be managed for sawlogs.

Where sufficient quantity and quality of hardwoods occur for new industry, hardwood management is essential. Hardwood management has other advantages that appeal to the general populace. It virtually eliminates objectionable herbicide use and is more compatible with other resources such as wildlife and range cattle. Also, it does not present as high a fire hazard compared to coniferous stands, and its short rotations are appealing.

Therefore, I would recommend a halt to any conversion projects, particularly in the Peace. Forest Managers throughout B.C. should rationally consider what the future may bring, when contemplating reconstituted wood products and planning future forests. An important question is not how much hardwood conversion is required, but whether it is required at all.

Long-term Silviculture Contracting

by
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INTRODUCTION: HOW TO CHANGE DUMB THINGS IN THE FOREST

The first work that I did in British Columbia was contract falling on the Williston reservoir. I was straight out of college. Flooding the Finlay and Parsnip bottoms seemed an idiotic thing to do to the most productive forest land. As I have been involved in the silviculture industry, I have gradually awakened to the fact that, if I want to change dumb things being done in the forests, I have to act on a political level — that means at the level of public awareness. The most effective pressure on the politicians is through the public press. This realization made it necessary to evolve simple goals that anyone could recognize.

These are my goals:

1A) MAINTAIN THE PRODUCTIVE FOREST BASE: "CURRENT REGENERATION OF ALL AREAS DENUDED"

The first goal — and it is a phase of public awareness — is recognizing the importance of maintaining the forest base. We have been losing the productive forest base as we log more than we reforest. Bill 70, passed in December 1987, prescribes steady-state, 100% reforestation. As long as industry practises what this new legislation prescribes, reforestation will be current with logging, and we will not lose more of our productive forest base.

1B) RESTORE THE PRODUCTIVE FOREST BASE

In the past era of harvesting we have created extensive areas of not satisfactorily restocked (NSR) lands, known as backlog, throughout the interior of the province, thereby eroding the productive forest base. This backlog is currently divided into two obligations:

a) Pre-FRDA. Backlog created before 1 January 1982; this is estimated at 1.7 million ha.

This backlog is targetted to be cleaned up under FRDA II and FRDA III. To rally action on this first obligation, in March 1987 I threw out a banner to both the provincial and federal governments: "Eliminate Backlog by the Year 2000". On 15 January 1988 at the Western Silvicultural Contractors' Association (WSCA) annual general meeting, B.C. Minister of Forests Dave Parker announced that his government is committed to eliminating backlog by the year 2000. This would require a FRDA expenditure of \$800 million. The federal government has still not indicated the level of its commitment to a new FRDA II.

b) Post-FRDA. Backlog created during FRDA and in violation of a provincial promise not to create backlog while the federal government funds the elimination of old backlog.

WSCA letters to the federal and provincial governments reminding them of this broken promise may have stirred some action. On 15 January 1988, at the WSCA AGM, the province promised that it will reforest all of this backlog created since 1 January 1982 during the next five years. This involves more than 300 000 ha.

2) SUSTAIN THE SUPPLY OF FOREST PRODUCTS

My second, newly challenging goal is to get public recognition for the importance of sustaining the annual supply of forest products through silviculture.

Silviculture can produce both long-term and short-term benefits. In the long term, high quality plantation performance, commercial thinning, spacing and fertilization can produce mature forests sooner. In the short term, these long-term benefits are immediately reflected in accelerated growth. With accelerated growth we can sustain and perhaps increase the current annual allowable cut (AAC).

THE FORESTER'S EXPERIENCE AS A CHANNEL FOR PUBLIC AWARENESS

You, as foresters, have to be aware that whatever you individually communicate is what the public thinks is happening in the forests. You are the experts. Simply communicate honestly, and from your own experience! The only security the silviculture industry has is the clarity of the public perception and understanding of the importance of the work. Not only does your work have to stand up under public scrutiny — it has to stand out.

Long-term contracts are only possible in the context of a lucid public grasp of regeneration issues and priorities. We have to create that context.

THE PAST

I am going to give a long-term review, beginning in the 1970s, and look at the historical economics of tree-planting, current reforestation legislation, and finally the future need to sustain the supply of forest products through silviculture.

Initially, provincial goals were set in very simple terms of the numbers of trees planted. The public's concern was "Are we planting as many trees as we cut?" This is a very linear, one-dimensional form of thinking; however, this simplistic view fueled the first increases in volume of seedlings planted. The character of the silviculture industry is set by the political goals of the government, which in turn reflect the character of the public's awareness. The tree-planting industry has been a political manifestation of this simplistic public concern.

The tree-planting industry is just a response to the opportunities in the market place. It is astonishing to see how closely the growth in our companies' seedling volume parallels the growth of seedling volume planted in Canada, and in B.C.

THE ECONOMIC HISTORY OF TREE-PLANTING

I found examining the character of the tree-planting industry through its trends during its development to be fascinating. These trends have been my livelihood. They exhibit the strengths and weaknesses of the past silviculture industry. The following is a vignette of tree-planting history — a mini economic model of an early manifestation of public silviculture awareness.

These graphs are based on an amalgam of Ministry data, the grapevine and bidding and planting records from our archives.

It is interesting that the ups and downs in prices for the silviculture industry are largely a product of supply and demand (see Figure 1). During 1982-1985 the volume did not increase very quickly. High unemployment kept the supply of contractors and planters greater than the demand. Consequently, prices fell to their lowest levels.

Increases in supply are directly due to increases in public awareness of the urgency for reforestation. If the government's goal had increased to 238 million trees, as was planned for 1988, we would still have been in a bull market and prices would have risen again.

PRICE GRAPH

The 35% increase in volume in 1987 produced a 30% increase in prices (Figure 2). The increased volume required more planters, resulting in a higher ratio of inexperienced planters and a decline in production. Interestingly, the higher prices also contributed to a decline in production. Contract administrators, paying more, expected more. Planters trying to meet those raised expectations were less productive.

I expected that prices in 1988-89 would settle down a little bit, for one or two years, primarily due to industry setting contract conditions in practical ways that are designed to keep the cost down. In fact this year, it appears as if industry foresters, anxious about meeting their free-growing obligation, are more rigorous and demanding about planting quality. This will lead to even higher prices per seedling.

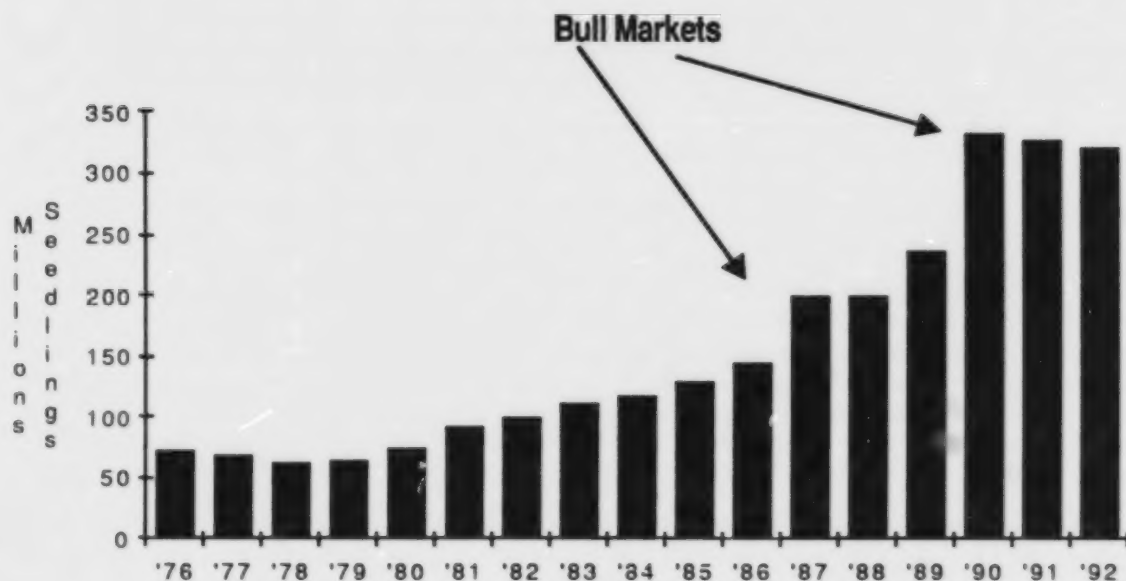


FIGURE 1. B.C. seedlings planted.

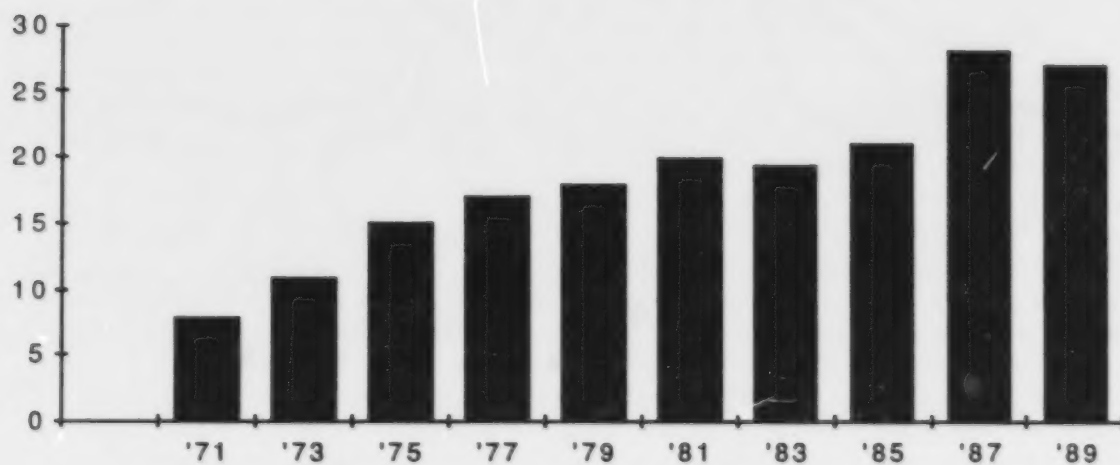


FIGURE 2. Estimated average cent per seedling.

PRODUCTION GRAPH

These data on the estimated average trees per planter day are rough. This graph does illustrate the trends, and the principles that govern those trends (Figure 3). The 1975 to 1983 gradual decrease in production is due to the gradual imposition of more demanding quality standards. Foresters are getting additional growth and survival value in exchange for the production decline.

In 1985 Ministry of Forests introduced a new quality checking system with a greater stress on intertree spacing, as a result of which I estimate that production declined by about 100 trees per planter per day. I question if as much was gained in plantation performance as was lost in production while trying to plant to the new checking system. The trees did cover more ground.

In 1987 production fell to 800 trees per planter per day. This was due to:

1. checkers and foresters who, paying more, expected more; and
2. increased volume resulting in an increased percentage of inexperienced planters, lowering the average production.

I am predicting a production increase of about 100 trees a day in 1989 because I expect industry to be a little more practical in how it administers contracts.

PRICE AND PRODUCTION TRENDS

As production decreases, price increases. The dynamic relationship between these two factors generates the economic trends of reforestation (Figure 4). Quality requirements translate into production factors and consequently price changes.

THE PLANTER-DAY COST TREND

Dollars per planter day cost is what contractors watch to see if the contract is going to work out or not; it is calculated very simply by multiplying the average price per seedling by the average trees planted per day.

You will notice that the dollars per planter day has held steady at a provincial average of about \$200 per day since 1975 (Figure 5). This is about \$50 below a healthy operating level. All figures are in current dollars; that is, the actual dollars per day paid. "Holding steady" is obviously not a healthy trend in an inflationary economy. Contractors have had to manage with the same dollars per planter day, year after year, while internal costs have increased with inflation, increasing quality demands and increasing complexity of reforestation.

COST TRENDS WITHIN PLANTING

Within this relatively steady dollars per planter day trend the dynamic of internal cost trends was not so steady (Figure 6):

1. the increasing cost of supervision was the result of increasing quality standards and complexity of stock handling and microsite planting requirements. Up to 1978 I personally made all my money as a planter and performed the function of a contractor, supervisor, quality checker, accountant, etc., on the side with minimal effort and as a service to my planting friends;
2. the cost of contract supplies increased steadily with the cost-of-living index. As the camp, Workers Compensation Board and stock handling standards became more rigorous, more equipment was required;
3. overhead appeared and then grew as a function of the increasing investment, complexity and risks of the business of contract planting (WCB audits, tax audits, Ministry of Health camp standards, etc.); and
4. the result of these irreversible cost trends was that the soft costs — labour, benefits and profits — were squeezed against the market ceiling of a steady dollars per planter day.

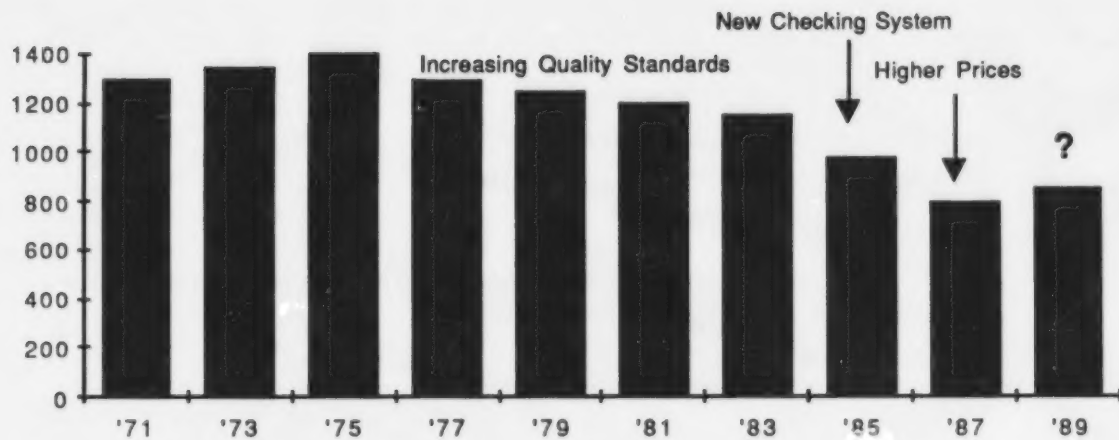


FIGURE 3. Estimated average trees per planter day in B.C.

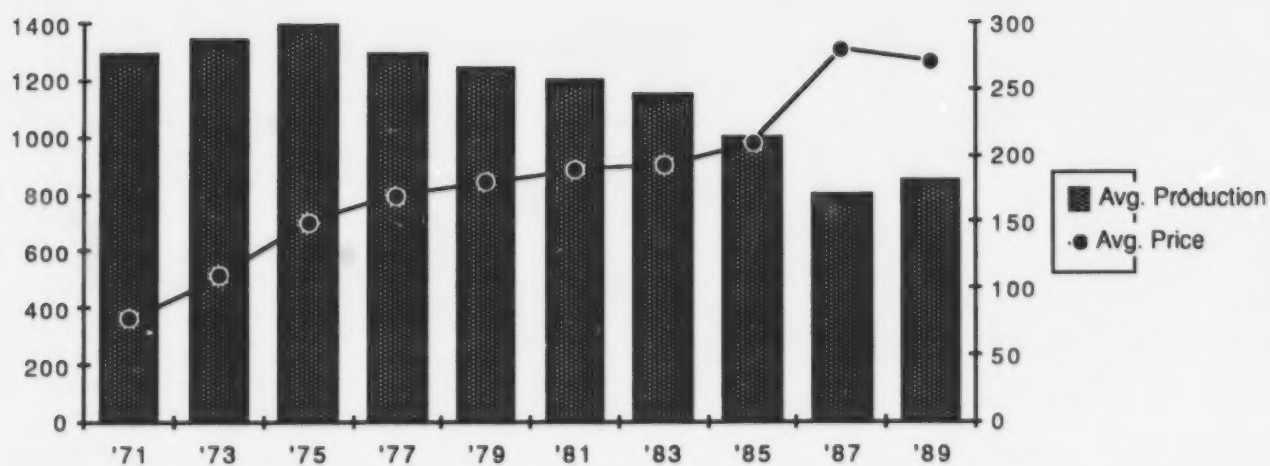


FIGURE 4. Rough price and production trends.

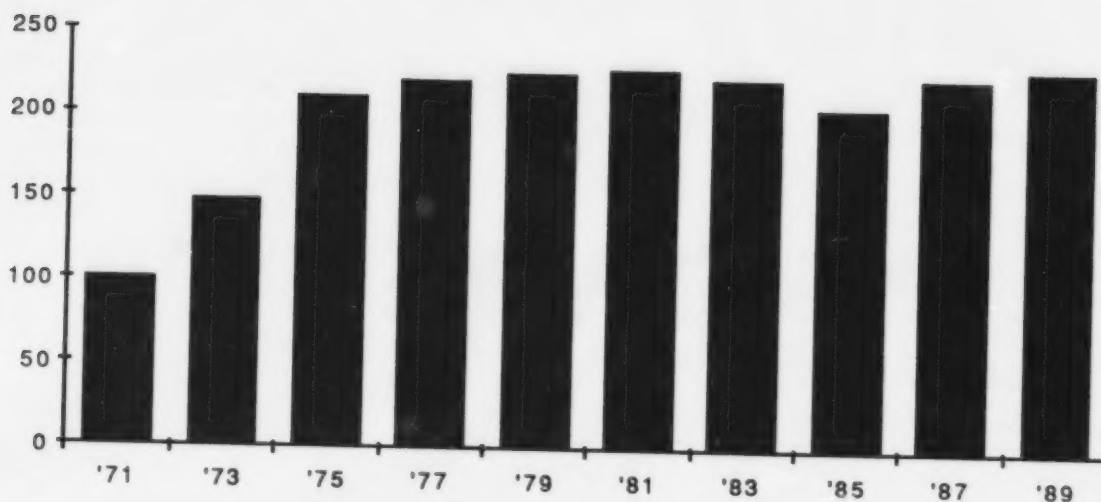


FIGURE 5. Approximate dollars per planter day.

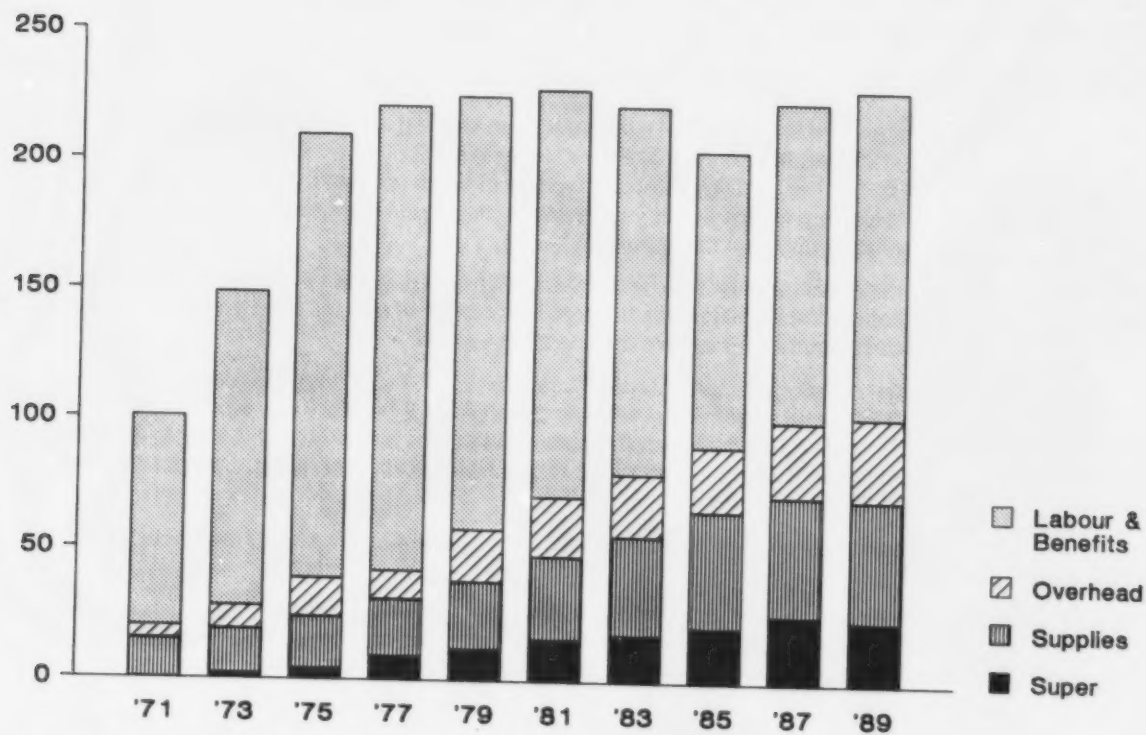


FIGURE 6. Approximate breakdown of dollars per planter day.

EXPERIENCED PLANTERS QUIT OR COMPLAIN

In Figure 7 I have adjusted these figures for the cost-of-living index during this period. This illustrates the decline in buying power for a day of planting. In the early 1970s I used to tree-plant for two to three months of the year and make enough money to climb mountains or kayak or build a log house for the rest of the year. In the 1980s that is no longer possible.

This explains the ludicrous phenomenon we have had in the tree-planting industry of contractors wanting to get rid of their experienced planters because they complain too much! It is not surprising that the experienced planters, who had become used to a high standard of earnings, were upset about the market trends. What is unfortunate is that they blamed their contractors. Not all planters were willing to accept their contractor's explanations. Some contractors introduced the policy of eliminating the complainers — i.e., the old timers, i.e., their experienced planters.

The loss of experienced planters has direct costs in forest survival and growth. Their craft and skill enables them to select a planting spot that is more advantageous to plant in — such a spot is almost always the best growing microsite for the tree. They can increase the growth of the plantation by 5 to 25%.

QUALITY VERSUS SPACING ISSUES

As a planter moves through the slash selecting each planting spot, the decisions that (s)he makes have a lot more to do with spacing issues than with microsite selection issues. This is in part due to the one-planting-quality checking system being uniformly applied throughout B.C. Most 'quality' issues in the checking system are manifest as spacing issues; correct spacing is often in conflict with optimum microsite selection.

A recent model permitting greater flexibility in spacing set up by Dr. Ken Mitchell in the B.C. Ministry of Forests Research Branch shows that there is a very minimal loss of volume at age 65 (probable harvest age) as the spacing increases in a Douglas-fir plantation. Latitude should vary with species and the uniformity of the microsite opportunities on each block.

CREATING A LOBBYING AND ORGANIZING PERSONA

From this overview, it is not hard to understand why I have been working hard to organize the industry and to lobby the Silviculture Branch and the Ministry of Forests over the past years. For a number of years I appealed to the Ministry to change the bidding system, or the way in which contracts were administered, or to emphasize the need to enforce regulations so that everyone is playing on the same playing field. These changes did not have a significant effect on the economic trends.

In 1983 Roy Strang confidentially showed me some interesting numbers and I woke up to the realization that there is another view that graphically illustrates the cost of the present regeneration system — or more interestingly, opportunities uncovered in the current regeneration system.

The total average cost per seedling of all phases of reforestation in 1982 was 83¢ per seedling. About two-thirds of the trees survived. The cost of a surviving seedling is therefore \$1.24 each. If you were to walk out and try to find the surviving seedlings now, only half would be pushing their tops out of the snow. That is, only one-third of the 83¢ seedlings are growing vigorously and will become free-growing seedlings. The cost of a free-growing seedling is therefore \$2.49 each.

I was confident that I could supply free-growing seedlings for less than \$2.49 in 1983. How could I arrange to supply such a service?

The one-dimensional structure of the regeneration program that the government had established did not have as a goal the establishment of a free-growing plantation. In order to change government regulations and legislation, I had to focus on changing the one-dimensional context of regeneration.

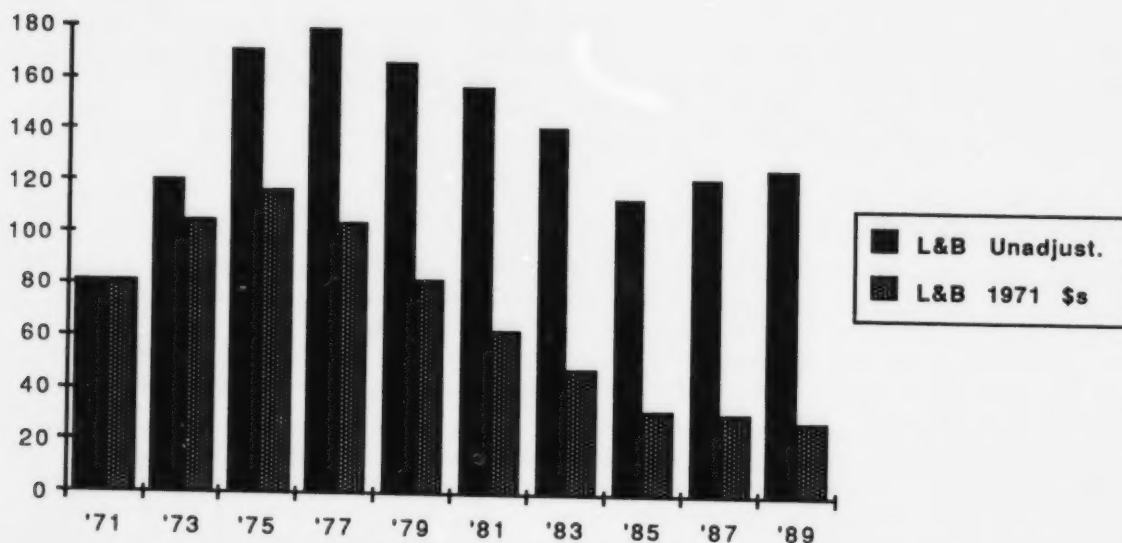


FIGURE 7. The veteran tree planter's perception.

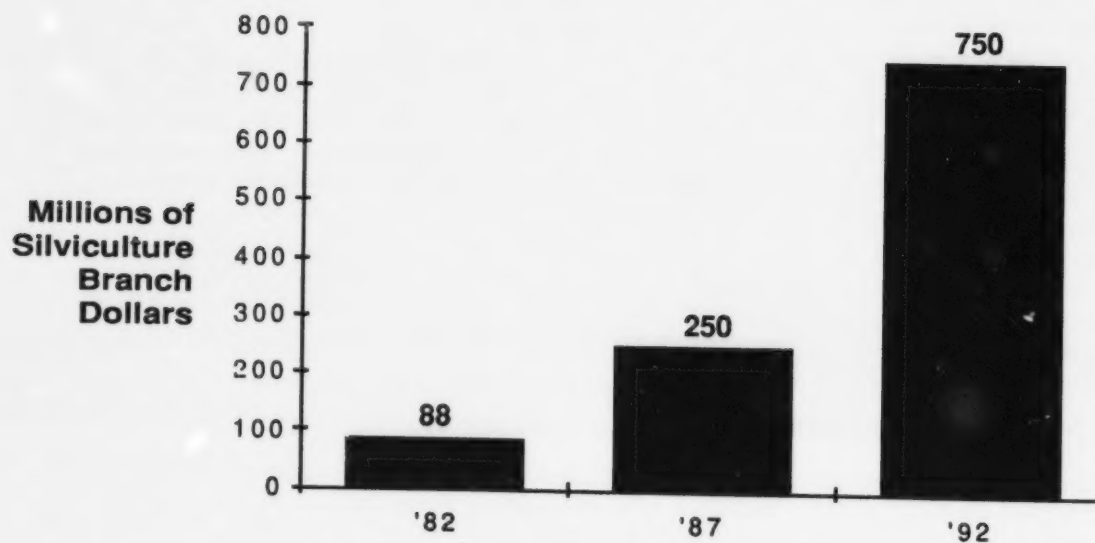


FIGURE 8. 1986 view from cabinet projected escalating costs.

ESCALATING SILVICULTURE COSTS AND THE NEW FOREST POLICY

Treasury Board and Cabinet had another perspective on reforestation costs. In their view the silviculture program costs were escalating out of control with no end in sight to the rising costs (Figure 8). If they did not want to lose their investment in planting they had tending obligations. If they did not want to lose their investment in tending they had fertilizing obligations. When planting prices increased 30% in 1987, Treasury Board also became aware of how vulnerable they were to the market trends in regeneration costs. Add the pressure from the U.S. to increase the cost of industry wood as manifested in the tariff threat and an export tax and you have most of the ingredients (just add this present government) for Bill 70. Industry now has the responsibility to regenerate all harvested areas at its own cost. This sets the stage for new possibilities in silviculture.

END-RESULTS CONTRACTING

Historically, the flow of events on a setting that leads from harvest to free-growing has not been administered from a continuous, integrated focus. This natural sequence of events is broken up into separate, distinct phases which are independently administered by separate Ministry of Forests departments (Figure 9). This was necessary initially because government control over these new regeneration processes required central administration which prioritized economies of scale that allowed expertise to develop in each phase.

The Ministry of Forests created the need to have a lot of communications between each of the departments administering the different phases of a natural flow of events on each setting. Each phase had its own set of rules and specifications to control the consequences it has for the other phases. All these separately administered phases create a bureaucracy of communications using provincially standardized forms in which site- and species-specific information is often lost. The predominant feature of such a busy bureaucracy is that it tends to be washing the dirty laundry, dealing with breakdowns, talking about what didn't work. Now that each of these phases is functioning it is appropriate that Vander Zalm is throwing out the washing machine. Fortunately, the forest industry has no intention of reconstructing this bureaucracy.

I envision silvicultural decisions being made as if from a pneumatic seat perched on top of the end-product free-growing seedling. As decisions are made at each phase, the decision-maker's free-growing height is affected.

Current forest policy does not provide for excellent plantations. It is simply a "stocking the productive forest with free-growing plantations" policy. It still lacks clear incentives for those who make these plantations' growth excel — it still lacks a clear end-results perspective.

It is difficult to establish which silvicultural practitioner excels without good plantation performance data. If plantation performance were tied to stand growth and yield and that in turn were tied into harvest and use value, outstanding plantation growth could be rewarded and encouraged. These incentives would not need to cost the Crown — the benefits could be designed to exceed the costs of the bonus for "incremental growth." It would be a true win-win policy. It is interesting that in stewardship contracts in the U.S., "free-growing" or satisfactory performance is simply defined as showing growth.

In any end-result contract the big issue is dividing up the risk factors. Bill 70 divides up these risk factors between industry and the Ministry of Forests quite simply — industry is responsible for everything: snow-mobile damage, logging damage, fires, disease, summer drought and extremes of frost. In a contractor-forest industry risk-sharing relationship, assuming a police role defending a plantation investment from all possible human damage is only possible for a local contractor.

THE SILVICULTURE CONTRACTOR'S VIEWPOINT ON HARVESTING

From an end-results perspective, how the forest is being harvested can have a major effect on the costs of regeneration and the success of the plantation. Ten years ago, a MacMillan Bloedel Ltd. manager once hollered at his silviculture forester who was requesting a grader to open a road for my planting crew, "It's logs in the water, not trees in the ground, that makes M&B go around." We walked in.

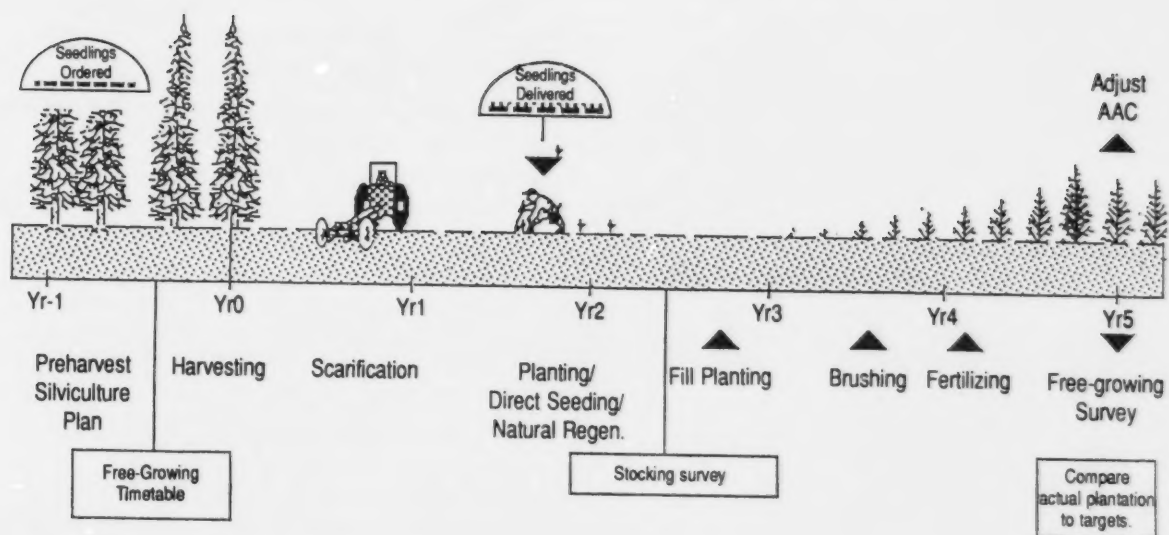


FIGURE 9. Free-growing tenure.

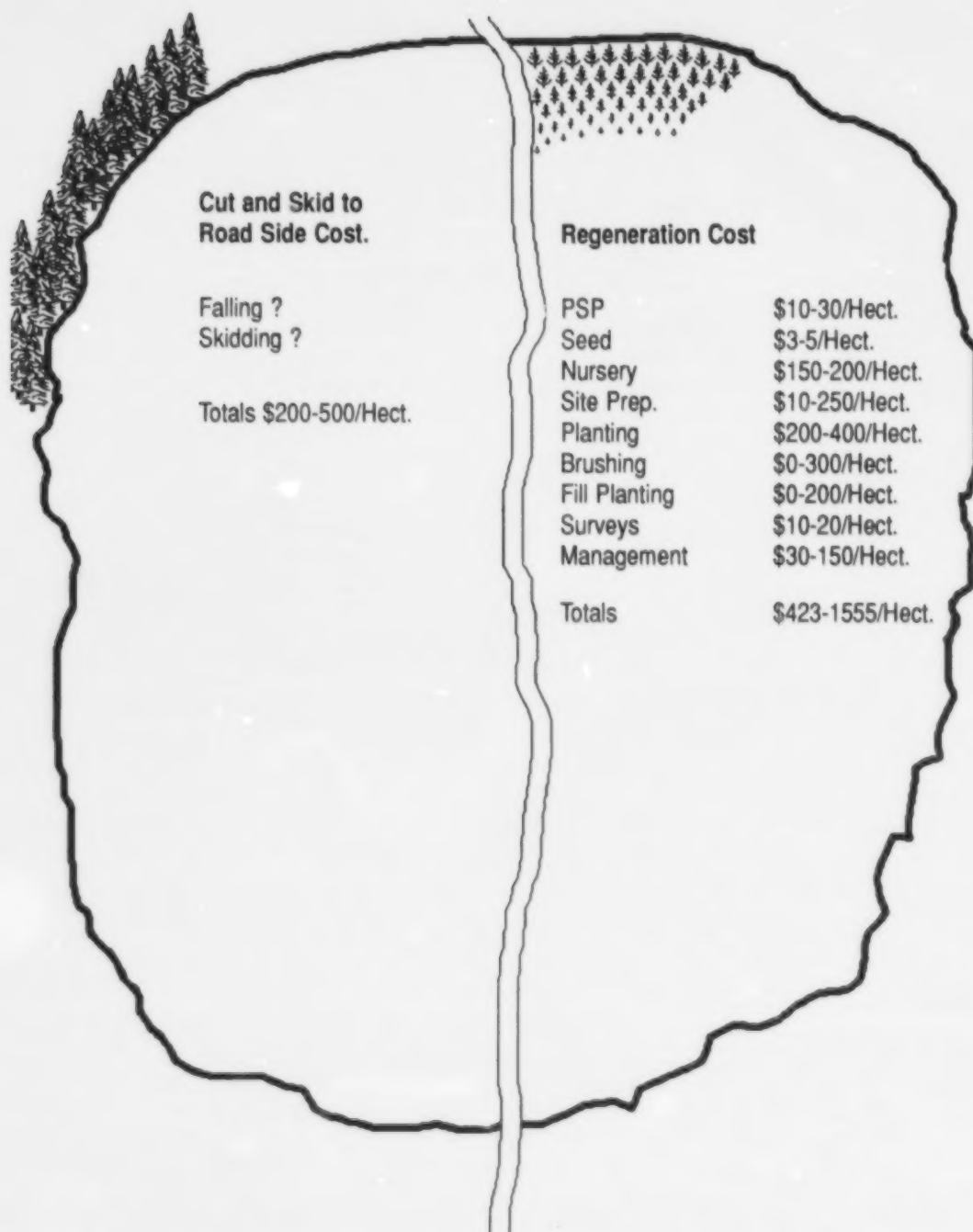


FIGURE 10. Harvest vs. regeneration costs.

Most foresters, having spent their career harvesting, share the logger's view of reforestation as a minor cost component of logging. Now that industry is responsible for the reforestation cost, that view is going to shift.

I have a regeneration point of view on a logging site. As I stand on the road (which I do not include in my cost formulae — I assume roads or access as given), I view the standing forest about to be harvested as a stand conversion problem (Figure 10). On one side of the road is summarized the cost of removing the mature stand; on the other, the cost of regenerating the area to free growth. It surprises most forest industry people that the per hectare cost of bringing the trees to the roadside is less than putting free-growing trees back.

This invites consideration of alternate logging methods which reduce the cost of regeneration. The high capital investments in logging equipment may allow only slow changes. At the least, the introduction of wide tires for skidders to reduce soil compaction and increase plantation growth will soon be common.

THE FUTURE OF SILVICULTURE

The future depends on taking the public awareness of the forests further, deepening its understanding of how to sustain the supply and preserve the integrity of the forest base. The end-results perspective takes the evolution of public awareness to the next phase. What began as a tree-planting industry and evolved into a reforestation industry is now beginning its evolution into a silviculture industry.

Two difficult phases lie before us. The first is the integration of ecological values, the second the integration of the enduring values of wilderness. The resolution of increased pressures on the remaining land base depends upon cooperation between the forest industry and the environmental movement.

The logging industry depends upon the goodwill of the public for its wood. Without a sustainable supply of forest products to give to the forest industry, the public will soon insist on thrifty government allocation and renewal of cutting rights.

Practically, this depends on the Mean Annual Increment (MAI) of growth in the unharvested and second-growth forest. In B.C. the MAI has simply been the rate at which the forests grow — without any assistance. This is about 3 cubic metres per year per hectare in B.C. In Sweden, the MAI is about 10 cubic metres per hectare on generally poorer forest soils. It is clearly possible to increase the MAI of B.C.'s forests significantly.

Up until 1 October 1987 the MAI was completely the responsibility of the Ministry of Forests. In the new forest policy, increases in the AAC or MAI created through intensive silviculture are the property of the quota holder. This is a new initiative. As the only incentive, it is inadequate to fuel the needed level of intensive silviculture required to sustain the AAC. The beneficiaries of increased harvesting volumes are not only the forest industry; the provincial and federal governments and the people of the province also benefit.

Historically, the AAC has increased 2% per year over the last forty years (Figure 11). If we project these trends into the future, the AAC would be over 200 million cubic metres per year by the year 2040 (Figure 12). How much harvesting can B.C.'s productive forest base support? This depends on the capacity of the silviculture industry to increase the MAI of the second-growth stands. It also depends on the harvesting industry to continue to increase the level of utilization and diversify into utilizing aspen and birch.

Incremental silviculture could add up to \$3 billion in added shipped value (Figure 13).

How much of an injection of intensive silviculture funds will be required to reverse the falldown effect is still unknown. What is a good rate of return? If we invest another \$300 million per year, will that make the difference that sustains \$3 billion in value of shipments? If for every \$1 invested by government, \$10 in exports are created, does this offer an adequate rate of return for a federal-provincial investment? Of the additional \$300 million per year for the next five years, some of it might reasonably be expected to come from the industry through incentives for increased AAC. If we look to FRDA II for \$200 million per year for the next five years, that by itself will require a \$1 billion commitment (Figure 14).

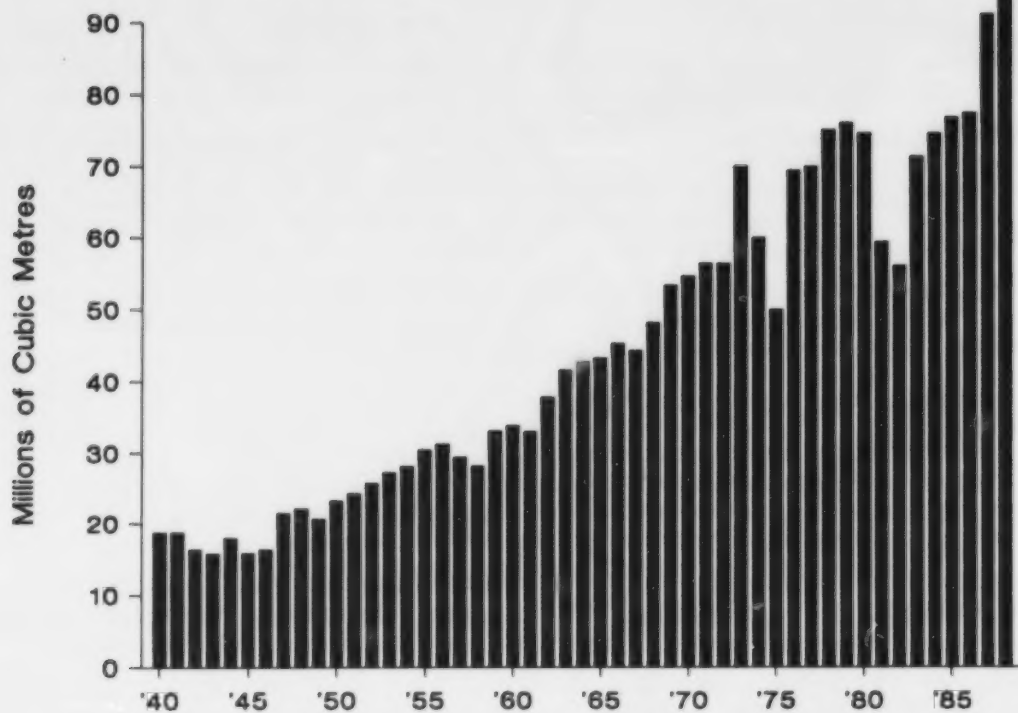


FIGURE 11. Annual harvest.

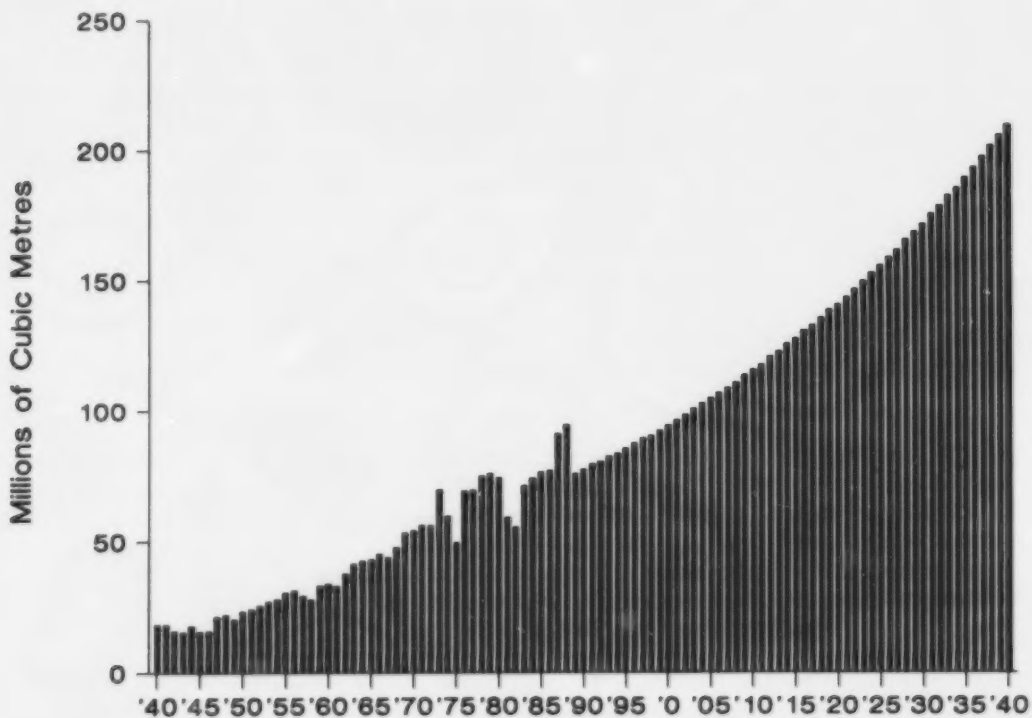


FIGURE 12. Projected AAC based on past trends of 2% increase per year, 1940-2040.

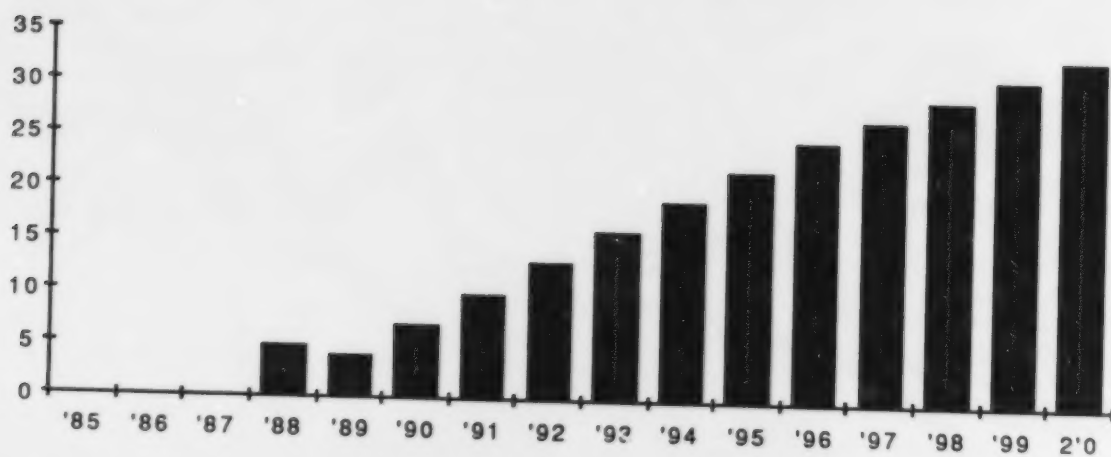


FIGURE 13. Value of incremental silviculture to annual harvest.

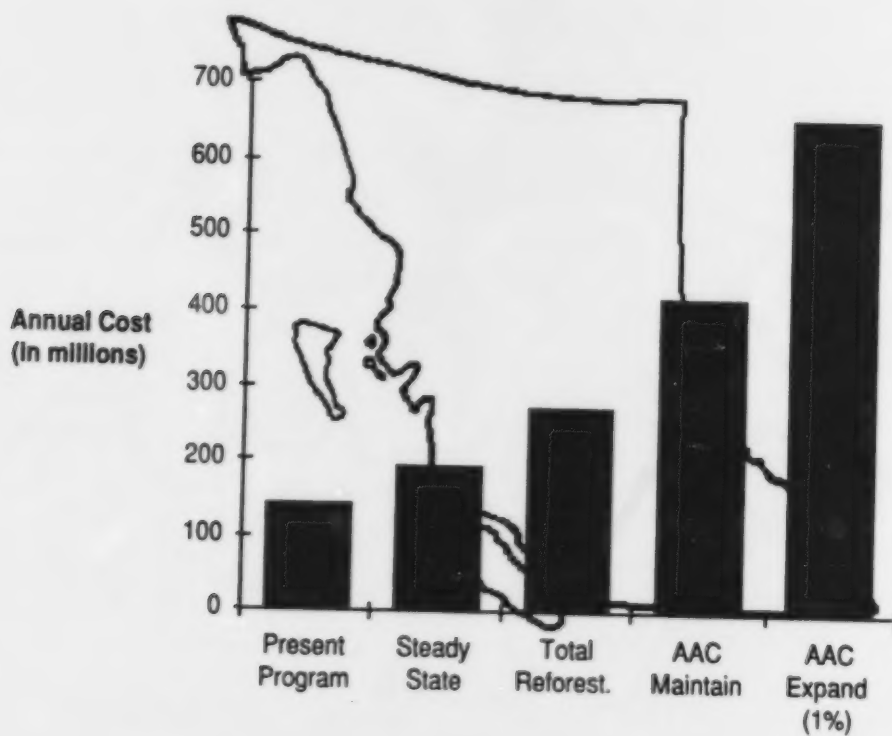


FIGURE 14. The cost of catching up.

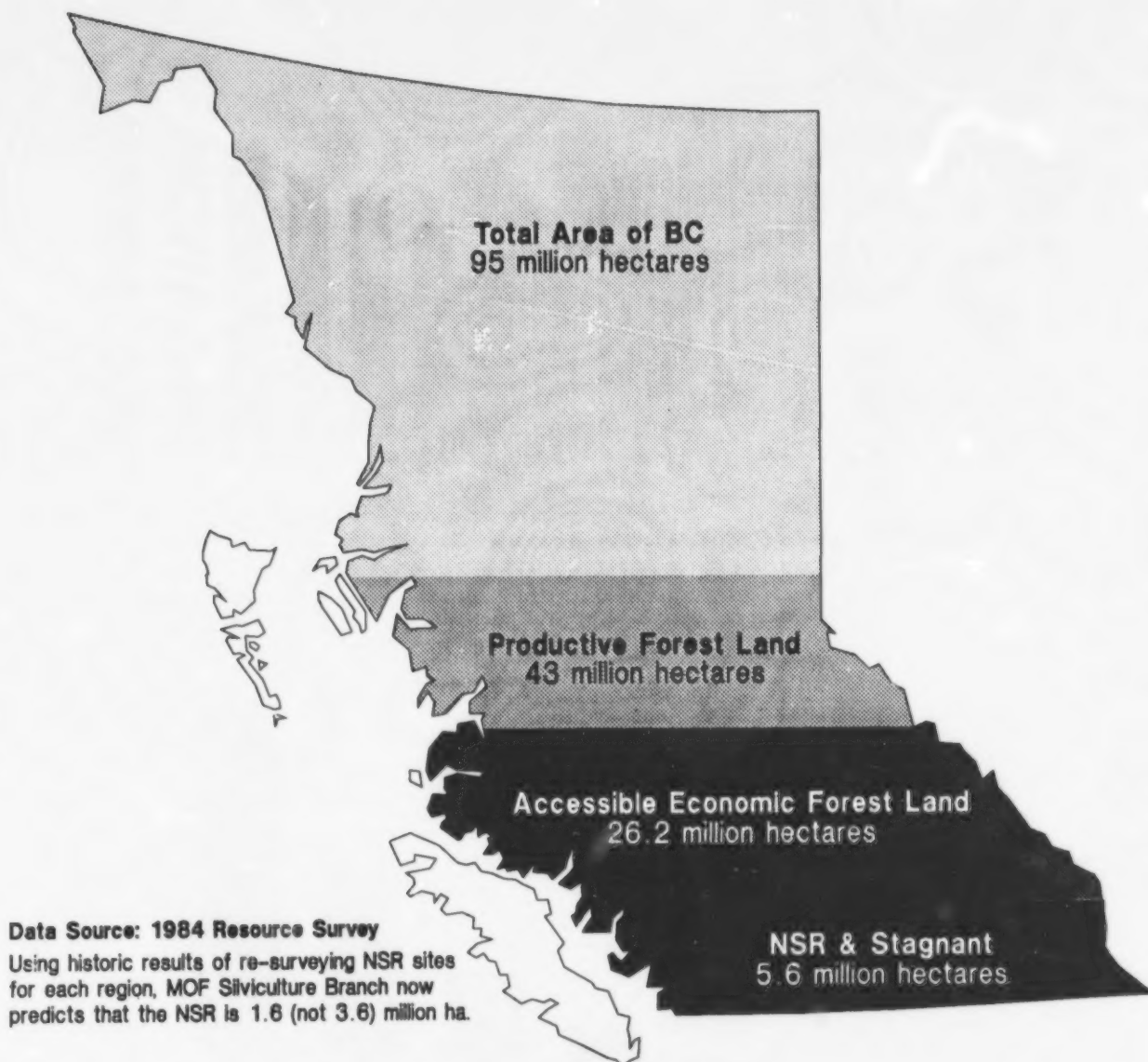


FIGURE 15. Next: cleaning up the backlog.

ELIMINATING THE BACKLOG

Remember that in addition to the socioeconomic incentives for FRDA II to turn around the falldown effect there is the job of eliminating the backlog. It is estimated that 1.7 million ha of the current 3.6 million ha of NSR will still need treatment by the time we could reasonably project organizing for the treatment of the backlog (Figure 15). In other words, by the time we get around to it, 2 million ha of the present backlog will have restocked with natural plantations. The projected MAI of these natural plantations will be significantly below the potential performance of artificially regenerated settings.

Of the 1.7 million ha of NSR, 1.1 million ha are classed as good and medium sites. If we were to eliminate the backlog by the year 2000, starting in 1990, we would have to plant 170 000 ha per year on average. At a modest cost of \$1200 per ha, this alone would require a FRDA II of \$1 billion ($\$1200 \times 170\,000\text{ ha} = \$204\,000\,000 \times 5\text{ years} = \$1\text{ billion}$).

Is there any hope at all for a FRDA II of \$2 billion? Perhaps not. The federal Minister of Finance will remain determined to reduce the deficit. Knowing this, the silviculture and forestry community has been involved in an internal debate about the appropriate priorities for each of these urgent needs. Foresters say things like, "There is too much focus on reforestation." We have to abandon our internal debate and get both the "Eliminate the Backlog" and "Sustain the Supply" messages out to the public where this debate will be resolved in either case. Let's not be afraid of the magnitude of the problems we have created and begin modelling the growth/yield/value curves and the socioeconomic benefit analysis to present our case.

SEEDLING VOLUME IN THE FUTURE

The number of trees to be planted based on the recent five-year plan tabled by Cabinet shows a dramatic increase in the next few years (Figure 16). In a bear market, with the volume increasing dramatically, planting prices will increase and good crews will be hard to find. Industry foresters presently working with good contractors will want to secure them to a long-term contract. Contractors will be reluctant to commit all of their resources to long-term contracts. The open market, during a period of increasing demand for contractors which will result in increasing prices, will be more profitable for contractors than long-term agreements with fixed prices. Foresters who have good contractors capable of assuring their free-growing plantations will be well advised to secure their contractors to a long-term commitment and pay them reasonably well to keep that commitment.

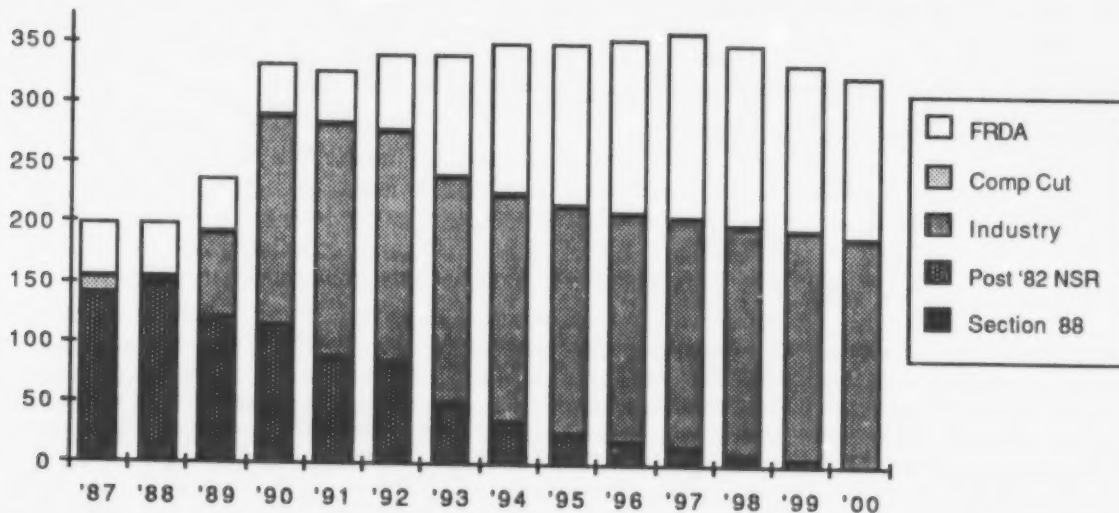


FIGURE 16. Seedling volume in the future.

An Appraisal of Site Preparation Machines

by
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The Forest Engineering Research Institute of Canada (FERIC) has participated in three mechanical site preparation projects with the Silviculture Branch, Ministry of Forest and Lands (MOFL). These projects were funded in part by the Canada/British Columbia Forest Resource Development Agreement (FRDA) Project 1.10. The studies under this umbrella project address the effectiveness of equipment in meeting prescriptions in sub-boreal forests:

1. the Sinkkilä HMF Scarifier was tested and monitored by FERIC on two sites during the 1986 field season;
2. the physical characteristics of mounds produced by the Sinkkilä, the Bräcke Moulder and the Ministry Moulder were measured in 1986 and 1987 at four study sites; and
3. a series of productivity studies were conducted on six powered disc trenchers.

Other FRDA projects are investigating the biological aspects of site preparation.

THE SINKKILÄ HMF SCARIFIER

The Sinkkilä is a spot scarifier manufactured in Finland. It was designed to provide intermittent scalps, continuous shallow furrows, or mounds, depending on the angle of the ripper and the hydraulic braking applied to it. The 1986 trials were characterized by two contrasting results: frustrating downtime and poor availability of the scarifier; and well-formed inverted humus mounds that it was possible to create with the equipment. On a windrowed site at Hudson Hope, the Sinkkilä was successful in 76% of the mound attempts. Productivity on that site was 1.94 ha/Productive Machine Hour (PMH). The second site near Vanderhoof had typical slash loading for logged areas, but the Sinkkilä was malfunctioning and results were poor. Details of the study are available in FRDA Report 006 (FERIC SR-40).

The unit was then modified by Forest Lease in Edmonton and used on a limited basis in Alberta in 1987. Its activity in 1988 will depend on interest in evaluating modifications made to the unit.

ASSESSMENT OF INVERTED HUMUS MOUNDS

The MOFL established site preparation trials at Fort St. John, Dawson Creek, Mackenzie and Vanderhoof in 1986. Biological assessments over the past decade have shown greater growth response with increasing depths of mineral soil capping. FERIC described the inverted humus mounds produced by the Sinkkilä HMF scarifier, the Bräcke Moulder and the Ministry Moulder by measuring mineral capping as well as mound height, length and width.

Overall the Ministry Moulder had the greatest success in producing inverted mounds on all four locations. Acceptable mounds were created in 79-95% of attempts. It also had the highest percentage of mounds with mineral capping greater than 10 cm. The Sinkkilä was highly variable in its results, in part reflecting its frequent malfunction. Results ranged from 44-80% acceptable mounds. Finally, the Bräcke Moulder produced consistent performance with 70-80% acceptable mounds. Mineral capping greater than 10 cm was much less frequent than the Ministry Moulder (6-41% of attempts compared to 62-89% for the Ministry Moulder).

Spring reassessments to determine the effects of wintering were done in May 1987. The data have not been fully analysed, but initial examination suggests little change had occurred in the mounds. The results of the fall 1986 assessments are reported in FRDA Report 008 (also available as FERIC SR-44).

TRIALS OF POWERED DISC TRENCHERS

In 1987 four powered scarifiers were used in British Columbia: the Donaren 180D and 280, the TTS Delta and the Wadell Fräsen cone scarifier. Productivity assessments were done on three pairs of machines, with a TTS Delta in each pair. All machines were operated by contractors and the studies were located as follows: TTS/Donaren 280 and TTS/Wadell at Vanderhoof and TTS/180D at Tumbler Ridge. All scarifiers were mounted on JD 740 skidders; the equipment used on both Vanderhoof sites included V-blades. The TTS units were manufactured for the B.C. market and had a 2.5 m disc spacing. Generally, mounting the units did not prove difficult. However, the older skidders required modifications to their hydraulic systems to provide adequate flow. Serious start-up difficulties also occurred with the TTS Delta units. After defective components were finally identified as the cause of gear-box failure and replaced, the availability of the scarifiers improved.

FERIC's assessments followed the Standard Assessment Procedure established by the Canadian Forestry Service. The blocks within the productivity study were typical for many logged and backlog sites. Table 1 describes slash and soil conditions for the blocks.

TABLE 1. Slash and soil conditions on the study blocks

	Stumps no./ha	Slash Volume m ³ /ha	Slash Depth cm	Depth LFH cm	Mineral Soil cm	Stoniness %
Vanderhoof-MOF						
Donaren 280	585	105	8.1	7.7	24.6	91
TTS Delta	885	97	7.4	7.8	29.0	82
Tumbler Ridge-CFI						
Donaren 180D	639	169	16.8	13.8	29.9	69
TTS Delta	398	147	14.1	13.0	22.4	73
Vanderhoof-Westar						
Wadell	390	166	13.1	7.3	17.9	95
TTS Delta	278	115	12.1	5.2	20.7	89

The Vanderhoof-MOF site was a backlog area and had many small aspen saplings. In some portions of the blocks the saplings were very dense and impeded the implement. Trafficability on this site was excellent. The Tumbler Ridge site was the most difficult of the three. Rain and seepage kept soils wet; slash loading was very heavy adjacent to landings and where cottonwood had been felled. As well, the Donaren block had slopes to 30%. The Vanderhoof-Westar site was rolling in topography, with moderate slash loading. The soils in this area averaged 20 cm in depth to a stony layer that prevented easy penetration by the cones or discs.

The productivity and trench spacing data are presented in Table 2. The productivities reflect both the site conditions and the spacing between passes. The Tumbler Ridge blocks did not allow back-and-forth treatment. Slope, wet patches and irregularities in the blocks required more "dead-walking" and re-covering of ground than the other areas.

The trenches and berms produced by these implements will not be described in detail here (this information is available from the author). As plantable spots were assessed, the microrelief and microdisturbance of each spot was noted (Table 3). The along-trench prescriptions were met in all cases. Raised slope positions with combinations of mineral soil and humus were considered the most desirable positions, although interface locations were also acceptable. At Tumbler Ridge, the deeper LFH and heavier slash loading reduced the penetration of the trenchers into mineral soil. This is reflected in higher proportions of plantable spots in interface positions and in humus. At Vanderhoof-Westar, occurrences of mineral soil on raised slope locations were higher for the TTS. As the discs rotated, the edges caught the stones within the profile and drew them to the surface. The result was a mineral soil berm. On the Vanderhoof-Westar site the Wadell remained above the stones and provided a mixed berm.

TABLE 2. Productivity of Donaren 180D, TTS Delta and Wadell at three sites

	Area Treated ha	Productivity ha/PMH	Between Trencher Distance m	Between Pass Distance m
Vanderhoof-MOF				
Donaren 280	11.5	1.57	2.26	2.51
TTS Delta	9.4	1.64	2.35	2.70
Tumbler Ridge-CFI				
Donaren 180D	9.5	1.09	2.24	3.32
TTS Delta	7.1	1.33	2.33	3.68
Vanderhoof-Westar				
Wadell	14.3	1.16	2.56	3.31
TTS Delta	10.3	1.26	2.33	3.86

TABLE 3. Assessment of plantable spots

	Prescribed Spacing m	Assessed Spacing	Interface	Microrelief %			Microdisturbance %		
				Raised Slope	Level	Other	Mineral Soil	Humus	Combination
Vanderhoof-MOF									
Donaren 280	2.7	2.73	38	52	4	6	19	7	74
TTS Delta	2.7	2.71	30	68	2	0	14	6	80
Tumbler Ridge-CFI									
Donaren 180D	2.8	2.81	66	20	14	0	4	16	80
TTS Delta	2.8	2.81	36	49	8	7	4	21	75
Vanderhoof-Westar									
Wadell	2.7	2.61	35	49	16	1	26	5	69
TTS Delta	2.7	2.69	25	63	10	2	59	8	34

CONCLUSION

On all three sites the implements provided the desired result. In the future, contractors will likely base their choice of implement on its flexibility and reliability. The two disc trenchers are seen as more flexible than the Wadell cone scarifier, and this may lead to their greater use. The Wadell gives excellent results on areas with lighter soils and thinner organic horizons but is more limited than the disc trenchers as conditions become more severe.

The FRDA 1.10 mechanical site preparation trials are providing valuable information on equipment entering the province. As the biological results come from other FRDA projects, the success in setting site preparation prescriptions and in carrying them out will be improved.

Response of Soil Climate in the SBSe Subzone to Microsite Alteration

by
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This study compares the effectiveness of various types of mechanical treatment in alleviating environmental factors which may limit spruce seedling growth in three site types in the Sub-Boreal Spruce (SBS) Zone of north-central British Columbia. The experiment is located at Joel Lake (elev. 1010 m) in the Morice Forest District north of Houston in the SBSe subzone (Pojar *et al.* 1984). Mounding, plowing and scalping treatments, created manually to simulate mechanical effects, were applied to study plots with mesic, subhygric and hygric moisture regimes. In late May 1987, Interior spruce seedlings (1+0, PSB 313) were planted in each of the treated spots. This paper reports on soil moisture and temperature responses observed during the first field season. Effects of treatments on seedling root growth and nitrogen availability are also being examined.

SOILS AND TREATMENTS

A key feature of soils in the Joel Lake area is a strongly compacted layer of basal till (Figure 1) which restricts drainage and results in a perched water table. Where the overlying layer of non-compacted mineral soil is shallowest, deep forest floor layers have accumulated. The rooting zone in these areas remains near saturation until early July, resulting in low temperatures and poor aeration. These conditions contributed to extremely low rates of survival and growth among spruce seedlings planted in 'hygric' and 'subhygric' portions of the area in 1984 following broadcast burning.

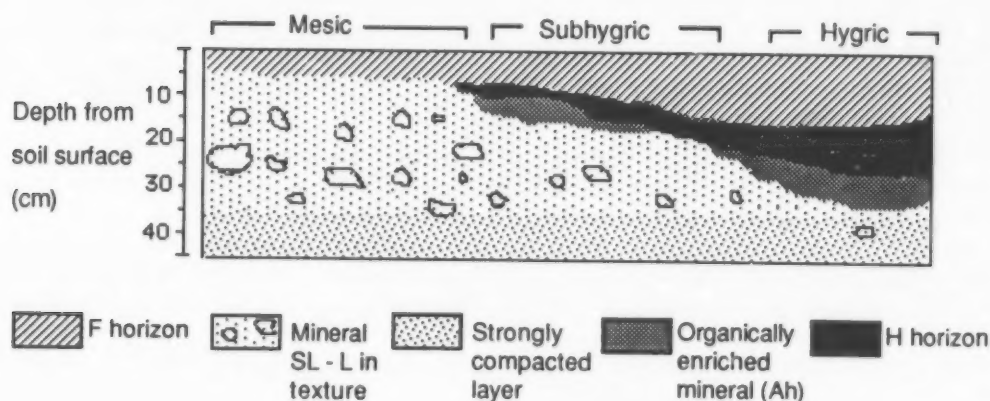


FIGURE 1. Diagram of soil profiles associated with mesic, subhygric, and hygric study plots.

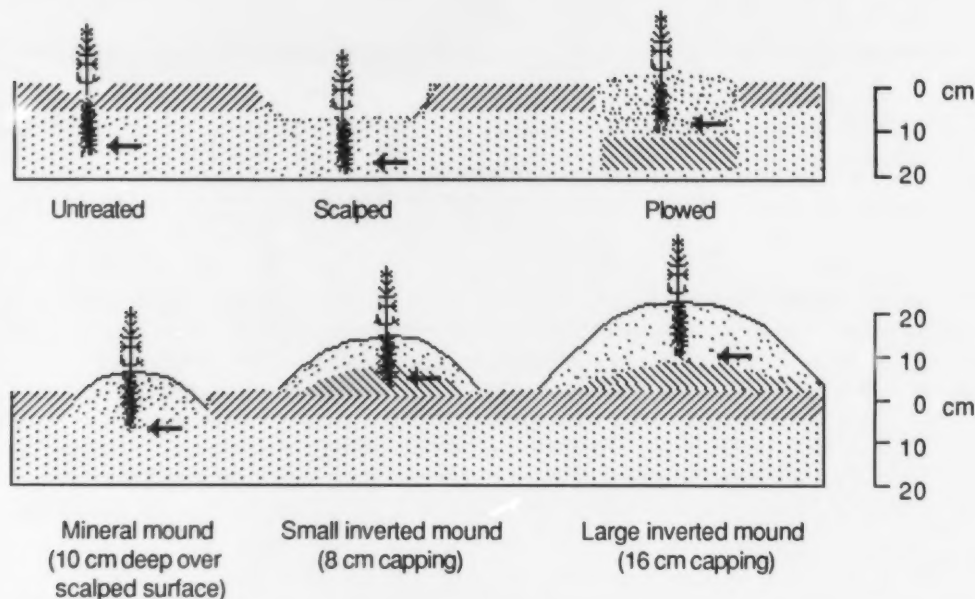


FIGURE 2. Diagram of experimental treatments with arrows indicating sensor locations. Diagonal lines represent slightly decomposed organic materials (F horizon), while dotted areas represent mineral soils in mesic plots, a combination of mineral and organic material in subhygric plots and well-decomposed organic material (H horizon) in hygric plots.

Experimental treatments are depicted in Figure 2. All six treatments were replicated in subhygric study plots. Mesic plots include all but the large inverted mound treatment, and hygric plots include all but the mineral mound treatment.

SOIL TEMPERATURE

Hourly average temperatures at a depth of 10 cm were recorded continuously by dataloggers beginning in late May 1987. Inverted mounds consistently exhibited the most extreme differences between night and day temperatures in all site types (12°C in July), followed by mineral mounds, plowed, scalped and untreated plots (2°C in July). The highest hourly average temperatures recorded in inverted mounds were 26°C in the hygric plot and 30°C in the mesic plots.

From late May to early September in the hygric plot, minimum temperatures in inverted mounds remained higher than those recorded in untreated and scalped spots, and from September to October 31, minimum temperatures were similar in all treatments within 1-2°C. At no time during this period did any hygric treatment drop below 2.5°C. Inverted mounds in the mesic plots tended to be more responsive to low air temperatures and occasionally fell to temperatures 4°C lower than those recorded in untreated spots during the growing season. From September to October daily minima were consistently lower in mounds, and by October 8 they had dropped below 0°C. Within 10 days, minimum temperatures in mineral mounds and plowed spots had also fallen below freezing, while scalped plots remained above 1° and untreated spots above 2°C up to the end of October.

Degree hours were summed for four five-day periods chosen to represent early, mid-, late and post-growing season conditions. By basing the heat sum calculation on hourly rather than daily average temperatures it was possible to detect differences in the occurrence of temperatures above the daily average among treatments having differing degrees of diurnal variation. The occurrence of these higher temperatures is of interest since seedling root growth has been shown to increase, and root resistance to water uptake to decrease significantly, at temperatures above 10°C (Grossnickle and Blake 1985; Grossnickle 1987). Degree hour sums for a base of 10°C are presented in Figures 3a, b and c and for 15°C in Figure 4.

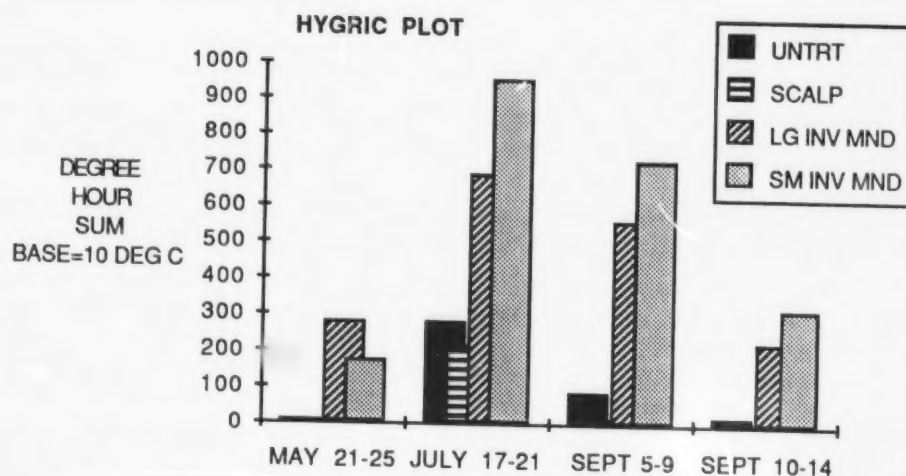


FIGURE 3a. Total degree hours > 10°C recorded at a depth of 10 cm in hygric treatments.

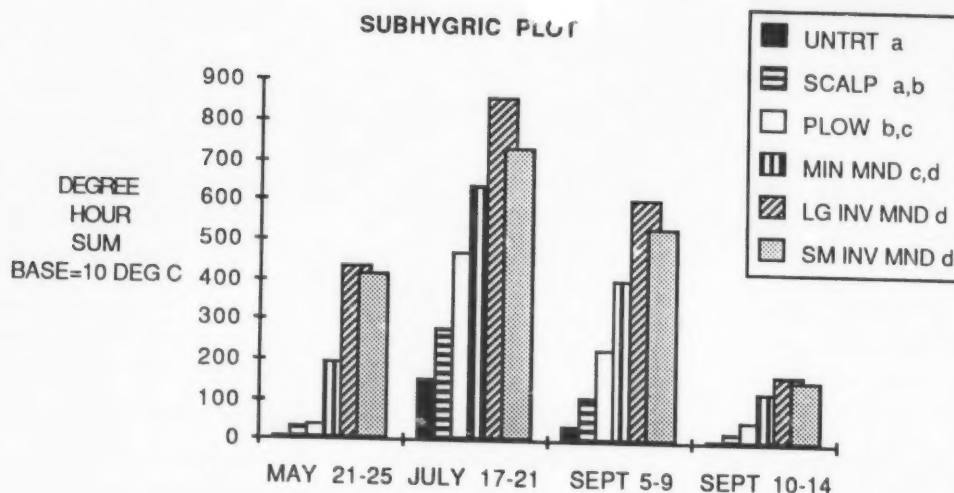


FIGURE 3b. Total degree hours > 10°C recorded at a depth of 10 cm in subhygric treatments. Treatments followed by a common letter are not significantly different during the July period ($P < 0.05$) as determined using Tukey's HSD mean separation test.

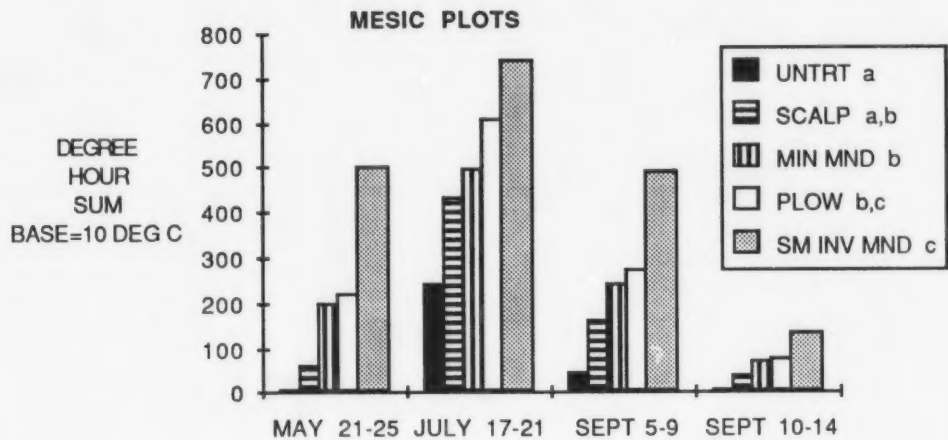


FIGURE 3c. Total degree hours > 10°C recorded at a depth of 10 cm in mesic treatments. Treatments followed by a common letter are not significantly different during the July period ($P < 0.05$) as determined using Tukey's HSD mean separation test.

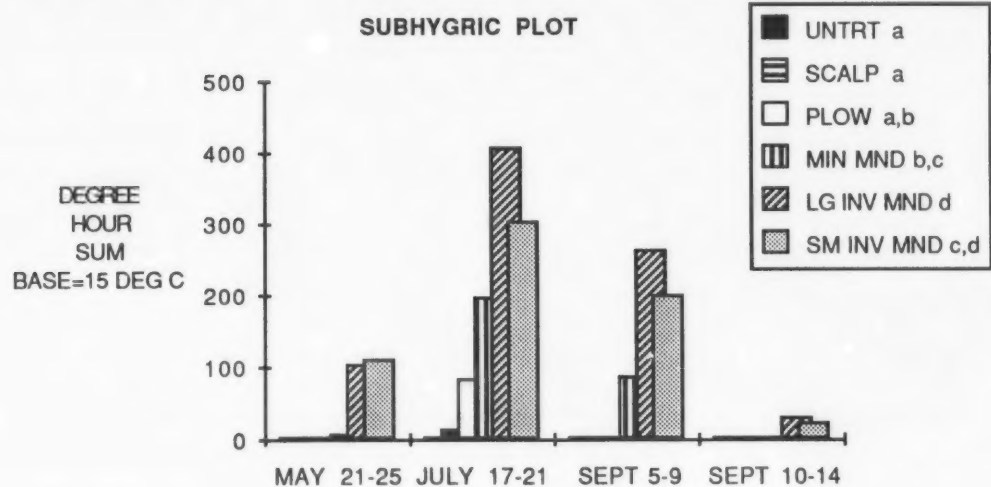


FIGURE 4. Total degree hours > 15°C recorded at a depth of 10 cm in subhygric treatments. Treatments followed by a common letter are not significantly different during the July period ($P < 0.05$) as determined using Tukey's HSD mean separation test.

Based on the occurrence of seedling root zone temperatures greater than 10°C, the 1987 growing season at Joel Lake can be broken into four periods (dates are approximate within 5 days):

1. an 'early' phase from mid-May to 24 June, during which only the mounded treatments achieved the base temperature for significant periods;
2. a 'warm' phase from 25 June to 9 August, during which total degree hours less than 10°C were at a minimum for all treatments and the differences among treatments are greatest;
3. a 'late' phase from 10 August to 9 September, during which total degree hours declined from the maximum but retained higher than 'early' phase levels and significant differences among treatments persisted; and
4. a 'post-growing season' phase beginning 10 September, after which the occurrence of temperatures greater than 10°C declined substantially in all treatments and differences among treatments diminished sharply.

In all site types, untreated spots were much slower than the treated spots to achieve temperatures significantly above 10°C in the spring, with one exception. The scalping treatment applied to the hygric site remained slightly cooler than the untreated spot throughout the season. Neither untreated nor scalped spots achieved temperatures greater than 15°C for significant periods in any of the site types.

Degree hour sums for bases of 5, 10 and 15°C were generally similar for plowed spots and mineral mounds in mesic and subhygric plots. Sums for these treatments were significantly lower during the early and late phases than for the inverted mounds.

SOIL MOISTURE

Gypsum resistance blocks, buried at a depth of 10-12 cm from the soil surface, were monitored at weekly intervals (Figures 5a, b and c). A tension of 0 bars indicates saturated conditions, while 15 bars indicates conditions of extreme dryness. Threshold levels of moisture tension relative to seedling response will vary depending on a number of factors, however, Mike Goldstein (pers. comm.) has suggested that a soil water tension value of 3 bars may be considered insufficient to provide significant growth.

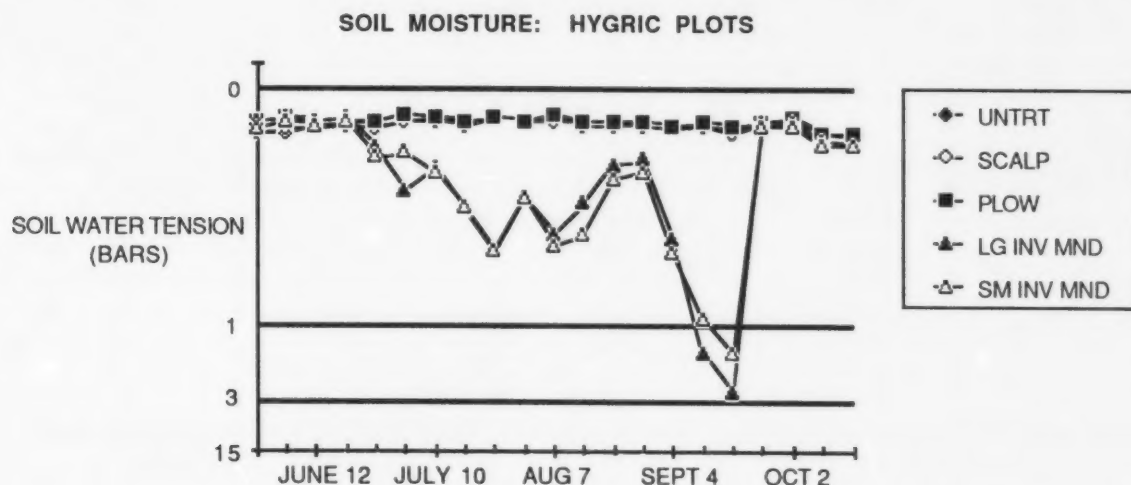


FIGURE 5a. Soil water tension for hygric treatments based on weekly readings of nine moisture blocks per treatment.

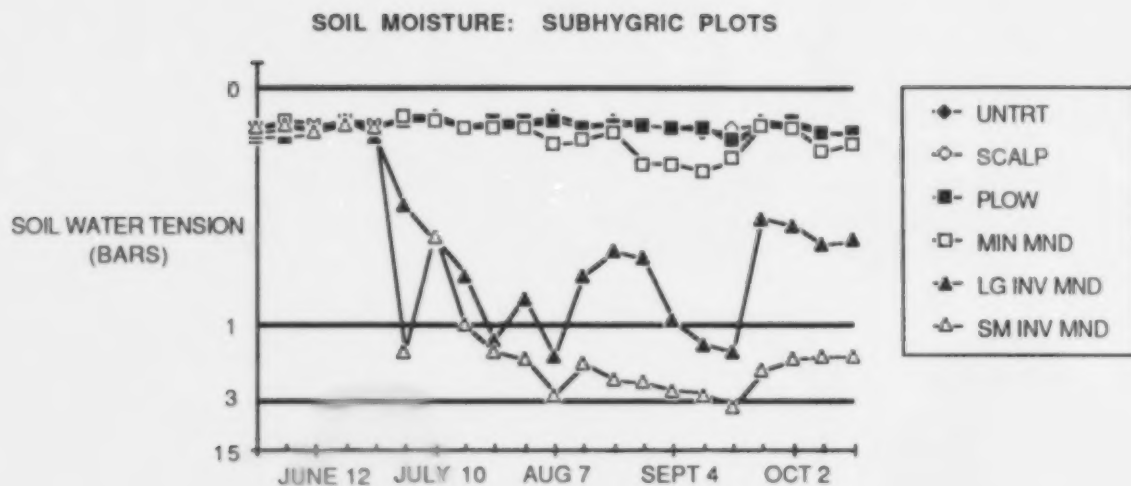


FIGURE 5b. Soil water tension for subhygric treatments based on weekly readings of nine moisture blocks per treatment.

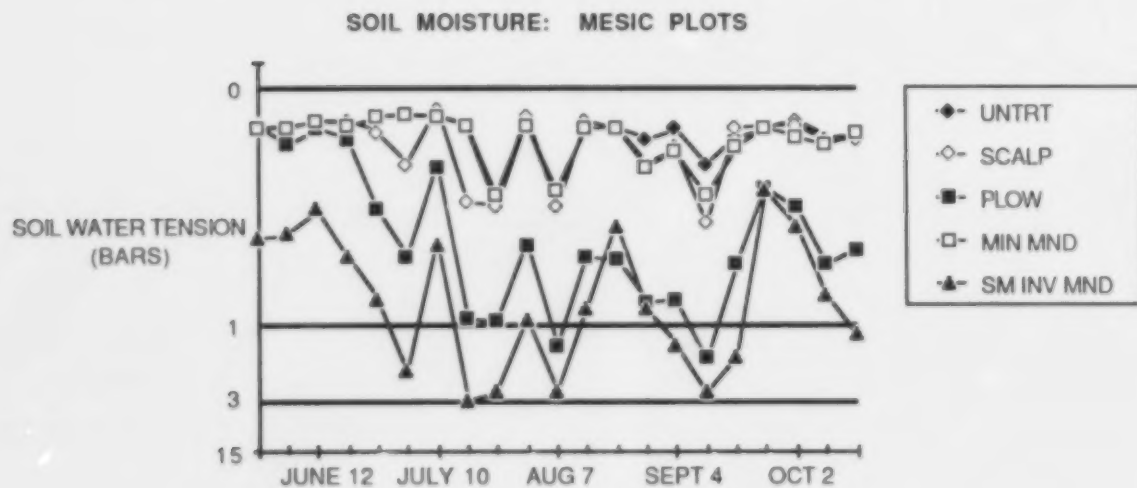


FIGURE 5c. Soil water tension for mesic treatments based on weekly readings of nine moisture blocks per treatment.

These data provide a general picture of moisture availability in the seedling root zone. Moisture levels in untreated, scalped and plowed spots varied little in hygric and subhygric plots, remaining high throughout the growing season. Variations in water tension were greater for all treatments in the mesic plots. Mesic plowed spots responded with markedly lower moisture levels than those observed in the plow treatments in other site types by the end of June. Mineral mounds in both subhygric and mesic plots remained in the moist range throughout the growing season.

In all cases the inverted mounds became drier than the other treatments, but the timing and degree of drying trends varied with site type. In hygric plots, large and small inverted mounds responded similarly, dropping to very low moisture levels only briefly in early September. In the subhygric plots, both sizes of inverted mounds had dropped to a level of approximately 1 bar by mid-July, but while the small mounds continued to drop to a very low level from that point, the large mounds remained moister and appeared to respond more readily to precipitation. The small mounds in the mesic plots were drier early in the season than any other treatment.

Standing water was observed in 15 of 25 scalped spots in hygric plots and in 13 of 25 scalped spots in subhygric plots at the time of planting in late May 1987. Although this study was not designed to examine the occurrence and effects of saturated soils, it is clearly a factor deserving attention in wetter ecosystems, particularly in association with perched water tables.

DISCUSSION AND CONCLUSIONS

Studies conducted under controlled conditions have demonstrated that seedling root growth and the ability of existing root systems to take up water are restricted at low soil temperatures. These findings coupled with the temperature data presented here suggest that low soil temperatures are contributing to slow growth and low rates of survival in Interior spruce plantations in the SBSe subzone. Seedling root zone temperatures in all site types did not achieve daily averages above 10°C in untreated soils until late June. Soils in mineral and inverted mounds and plowed spots reached daily averages above 10°C three weeks or more in advance of untreated soils. This early warming of the root zone may be particularly critical to seedlings immediately following planting, although the benefits of an extended growing season are likely to extend well beyond the first year (McMinn 1985a).

The success of rehabilitation programs may be enhanced by mechanical treatments aimed at improving soil temperatures early in the growing season. Treatment choice must take into consideration soil and site characteristics. Scalping did not improve soil temperatures over untreated levels in a hygric plot subject to a seasonally high water table. In addition to low temperatures, seedlings planted in this treatment were subjected to flooding early in the season, which is extremely detrimental to growth (Grossnickle 1987).

Inverted mounding resulted in soil water tensions periodically substantially higher than those observed in other treatments. Where materials capping inverted mounds had a very high organic matter content, as in hygric plots, drying effect appeared to be much less severe. In subhygric plots, mounds with a mineral soil capping 16 cm in depth retained more moisture than those with cappings 8 cm in depth. Mineral mound and plowing treatments resulted in increased soil temperatures in subhygric and mesic plots while having less marked effects on soil moisture levels than inverted mounds.

Assessment of the net benefits to seedling growth afforded by these treatments will be made based on measurements of root and shoot mass and foliar nutritional status in 1989.

Root Egress of White Spruce (*Picea glauca*) Seedlings after Outplanting as Affected by Patch and Mound Site Preparation

by
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INTRODUCTION

The backlog problem in the northern interior of British Columbia has been assigned a high priority. A number of failed spruce plantations form a large component of non-satisfactorily restocked lands, with low soil temperatures being identified as a major factor limiting seedling growth and survival (Butt, in preparation).

Mechanical site preparation will play a major role in overcoming this problem. The need for an operational assessment of various site preparation treatments over a range of representative sites, combining mechanical and biological assessments of successful planting, is obvious. This project proposed to use root egress as an indirect biological measure of the success of site preparation techniques in achieving favourable temperature and moisture conditions for seedling growth. Three of the treatments studied are included in this paper.

In spite of the general paucity of data describing temperature effects on root growth, the following relationships have been noted:

1. the optimum root temperature for total biomass accumulation in several coniferous and broad-leaf tree species, including white spruce, is between 19° and 23°C, although interspecies differences are evident (Heninger and White 1974; Ritchie and Dunlap 1980; Lopushinsky 1987);
2. reduced tissue nutrient concentrations may result from the direct effects of temperature on uptake and translocation (van den Driessche 1984; Chapin *et al.* 1983, 1986);
3. low root temperature also causes a decrease in water uptake, transpiration and stomatal conductance (Kaufmann 1977; Teskey *et al.* 1984; Babalola *et al.* 1968);
4. root temperatures of 2-5°C greatly limit phosphorus uptake of Douglas-fir seedlings (van den Driessche 1984), but this uptake is much greater for vigorous seedlings than it is for seedlings with poor root growth potential (Burdett *et al.* 1984). Bowen (1970) notes that the uptake of phosphorus is reduced by low temperatures;
5. soil temperatures of 8°C suppress root elongation more than they do new root formation in red pine (*Pinus resinosa*) seedlings (Anderson *et al.* 1986), but Nambiar *et al.* (1979) found that 5°C soil temperature dramatically reduced both the number and length of new roots on transplanted *Pinus radiata* seedlings; and
6. root growth of white spruce seedlings begins at 1°C (Stupendick 1974).

METHODS

White spruce seedlings were outplanted in the spring of 1987 on each of three site preparation treatments (deep mound, patch/scalp and untreated control) on each of three study sites located approximately 120 km northwest of Fort St. John (Iron Creek), 50 km west of Dawson Creek (Stewart Lake) and 15 km south of Mackenzie. The sites were mechanically site prepared in 1986 under FRDA Project 1.10 in a randomized complete block design, with five replications per treatment. The egress of new roots, from the root mass developed during the growth of the seedlings in styroblocks, was measured at 45, 70 and 95 days after planting during the first growing season. At the time of each assessment, the moisture stress of a sub-sample of each seedling population was measured. The 45 and 70 day assessments consisted of tallying the number of

actively growing new roots for each seedling. The 95 day assessment consisted of tallying seedling height, new growth, diameter and projected root area. The dry shoot and root weight, weight of 100 needles and foliar nitrogen and phosphorus concentrations were also measured for a sub-sample of each seedling population.

RESULTS

Results have been summarized in tabular form but as yet have not undergone statistical analysis of variance testing (see Tables 1-11). Seedling moisture stress measurements taken over the three assessment periods showed no treatment differences. No moisture stress was indicated for the 45 and 70 day assessments, and only moderate moisture stress at the 90 day assessments.

CONCLUSIONS

Root growth of seedlings planted on the mounds was generally superior to that of seedlings on either the patch or control areas. Such increased growth may reflect changes in both soil temperatures and soil moisture. Data recorded during the summer demonstrate that the mounds had higher soil temperatures than either the patch or control treatment, and the high water tables present over much of the Iron Creek and Stewart Lake sites were reflected by mortality of roots which had been initiated in the late spring. In contrast, the effects of the mound treatment on the Mackenzie site were probably restricted to the contribution of increased temperatures to root growth as a high water table during the growing season was not observed in this area. The difference, then, in the relative root growth of seedlings grown on the different site preparation plots in the Iron Creek and Stewart Lake areas from that of seedlings grown on the same treatment plots in the Mackenzie site doubtless reflects the influence of anaerobic conditions in rooting media of the former two areas.

The data reflecting nutrient uptake and biomass increment of seedling shoots do not reflect the differences expressed by the roots. However, all seedlings were found to have high height/diameter ratios which may reflect shoot growth limited by light. Continued examination of the plantation in the next two years will be necessary to determine if seedling shoot growth will reflect the same differences as that of the roots.

TABLE 1. Number of new root tips, 1 cm + (45 days after planting)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	11.42	12.80	28.44
Stewart Lake	4.50	3.50	14.12
Mackenzie	19.42	21.86	40.64

TABLE 2. Number of new root tips, 1 cm + (70 days after planting)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	21.22	14.16	49.88
Stewart Lake	17.94	8.44	44.12
Mackenzie	39.34	39.28	68.58

TABLE 3. Projected root area (cm²)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	62.03	55.76	79.43
Stewart Lake	57.71	57.38	80.30
Mackenzie	82.04	90.95	93.17

TABLE 4. Total seedling height (cm)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	29.92	31.22	33.47
Stewart Lake	32.98	34.31	33.41
Mackenzie	25.23	27.90	27.57

TABLE 5. Seedling height growth, 1987 (cm)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	11.75	12.38	14.66
Stewart Lake	12.09	14.00	12.04
Mackenzie	9.75	11.89	11.45

TABLE 6. Seedling diameter (mm)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	2.91	3.11	3.40
Stewart Lake	3.45	3.43	4.13
Mackenzie	2.83	3.42	3.20

TABLE 7. Total seedling dry weight (g)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	4.04	3.97	5.82
Stewart Lake	6.09	5.14	8.56
Mackenzie	3.48	4.62	4.47

TABLE 8. Shoot:root ratio

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	4.93	6.81	4.13
Stewart Lake	4.95	6.15	3.70
Mackenzie	2.26	2.42	2.58

TABLE 9. Foliar nitrogen (%)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	1.25	1.44	0.98
Stewart Lake	1.35	1.46	1.12
Mackenzie	1.65	1.29	1.45

TABLE 10. Foliar phosphorus (%)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	0.20	0.23	0.16
Stewart Lake	0.17	0.16	0.14
Mackenzie	0.26	0.24	0.22

TABLE 11. Dry weight of 100 needles (g)

Site	Treatment		
	Untreated	Patch	Mound
Iron Creek	0.163	0.157	0.186
Stewart Lake	0.140	0.145	0.158
Mackenzie	0.096	0.124	0.153

Use of the TTS-35 Passive Disc Trencher in the Ootsa and Nechako PSYU's

by
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Fraser Lake, B.C.

HISTORY

In 1974, Eurocan Pulp and Paper Co. Ltd., harvesting timber in the Andrew Bay area of the Ootsa Lake system, acquired its first TTS-35 disc trencher (Figure 1). That summer we prepared approximately 100 ha. Except in 1975 and 1976, it has been used since. In 1988 approximately 700 ha will be disc trenched by Fraser Lake Sawmills.

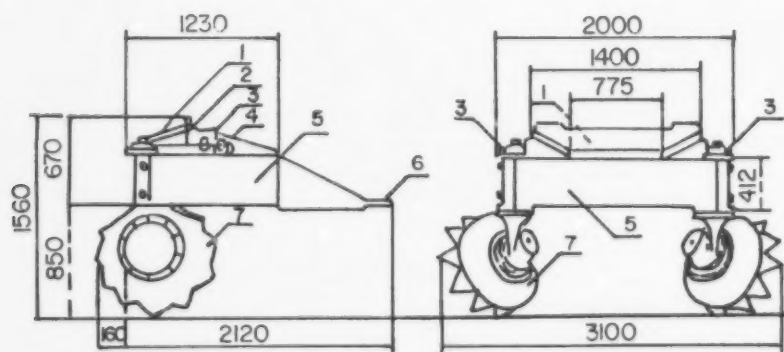
If broadcast burning is an option, it is always preferable to trenching. It will yield by far the most vigorous pine plantation with the least maintenance cost.

PRIME MOVERS AND MACHINE LOGISTICS

In 1974 we used a Clark 667 skidder which proved unsatisfactory. We then tried several crawler-tractors, among which the 82-20 proved to be the most suitable machine due to its high clearance, high flotation, speed and clean undercarriage.

During 1977 to 1979 we only had one disc trencher on site, resulting in much "stuck" time. In 1980 we used two disc trenchers simultaneously. There was an 80% reduction in stuck time with Cats by waiting a year after winter logging because most of our Ootsa soils are loam and clay loam tills which become saturated after exposure to frost during winter logging. These two adjustments minimized lost productivity.

Recently we began using the JD740 skidder as prime mover because, with it, a good operator can handle slopes and moist sites which cannot be done with a Cat. The ability to equip a JD740 with duals and chains all around increases its versatility. With the increased use of large skidders for towing our trenchers, a V-rake has been developed. This is a lightweight V-plow with five spring-loaded sliding teeth. The V-rake sidecasts large debris and aligns smaller material that would normally interfere with the trencher by not allowing it to reach the soil. Another advantage of a large skidder is its pony arch, which is used to lift the trencher during moving from site to site.



- 1 = Lid of the fuselage for extra weight
- 2 = Arm of the spring device
- 3 = Point of attachment of the spring
- 4 = Ring for lifting the trencher (1 on each side)
- 5 = Space for extra weight
- 6 = Pulling ring
- 7 = Disc

FIGURE 1. TTS-35 (all measurements in mm).

TRENCHER MAINTENANCE AND MODIFICATIONS

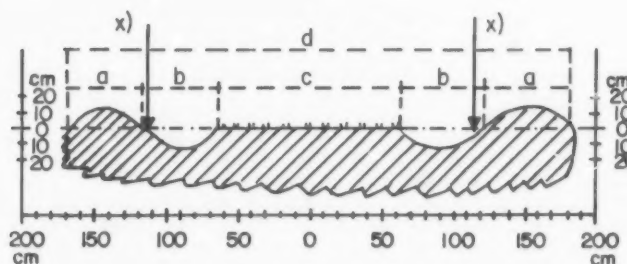
One of the first things that happened when the TTS-35 was put into our slash conditions was that it flipped over and broke the exposed disc angle adjustment mechanism. To correct this, rollover protection was added. The TTS-35's hollow body means that one can add or remove weight as needed for different soils and site conditions. However, bouncing or a rollover may cause some ballast to jam into the coils of the shock absorber springs, causing them, or the shock absorber shafting, to break. This problem can be solved by boxing in the spring system.

These were the major modifications needed to cut maintenance costs. Minor ones were the replacement of factory-issue Grade 3 bolts with higher grade ones throughout the machine, particularly on the discs. A special abrasion-resistant hard surfacing material used to face the AR steel of the disc teeth has almost eliminated tooth replacement and reduced frequency of hard surfacing the teeth.

Since 1980 the trend in our planting has been towards lower stocking per hectare. As a result we cut the trenchers in half and widened them to increase the distance between the trenches from 2.5 m to 3.0 m. This allows additional ballast to increase disc penetration; however, the incidence of fractures in the discs increased. These modifications resulted in a reduction in maintenance costs from \$20.00/ha to under \$5.00/ha.

MACHINE SUMMARY

With these improvements, machine productivity has increased from an average of 1.0 ha/hr to only 1.2 ha/hr — apparently not much gain. However, we now use the trenchers under increasingly more difficult conditions, which has masked improved efficiency. Moreover, the machines now achieve consistently excellent biological results, even on a rough block. Microsites are now much more uniform and available to the planter. Our trenching contract costs are now \$100.00 - \$120.00/ha. Reduced planting costs due to high-quality mechanical site preparation often result in recovering half or more of the trenching cost.



- a = Tilth
- b = Trench
- c = Untouched area
- d = Cross section section
- x) = Arrows indicate the best site (hinge) for planting or direct seeding

FIGURE 2. Cross section after trenching.

The quality and orientation of the trenches (Figure 2) are major factors in reducing planting costs. High quality trenches that provide superior microsites are continuous, clear of loose organic material, have a 15-20 cm deep trench, a tilth of 15-20 cm high, and are uniformly parallel, spaced 2.5-3.0 m apart across the treated area.

Trenches should be oriented north-south whenever the topography will allow — even if it means running up and down steep slopes. The north-south orientation maximizes warming of the exposed soil. If an east-

west orientation were used, one side of the trench would always be shaded. Trenches running up and down steep slopes do not create a soil erosion problem because they are not continuous, since they are interrupted by stumps, logs or rocks and have built-in waterbars.

Trenching with just one prime mover results in lower trench quality. If the trencher is towed on the mainline, it tends to go around obstacles rather than dig in as it does when attached to the drawbar. But, if the PM gets stuck while pulling the trencher on the mainline, it can release the winch and get away from the trencher, which it cannot do when the trencher is directly attached to its towbar.

Another factor which can affect trench quality is the depth of the duff layer. It is not advisable to use a passive TTS-35 trencher on areas with 10 cm or greater duff depths. The trench profile becomes more or less square, with little or no mineral soil capping on the tilth. Also, if the prime mover is not equipped with a V-rake, trench quality deteriorates quickly as slash loadings increase, and trenching is limited to lighter slash areas.

BIOLOGY OF DISC TRENCHING

Most sites that are trenched could very easily be planted raw, but it is a question of trading off pressures to cut initial establishment costs vs. pressures to ensure a free-to-grow plantation at fairly low cost. Preparing the site by trenching substantially increases chances to achieve free-to-grow within the required time period, because of increased seedling performance as well as a reduction in the likelihood of having to do additional work (see Table 1 and Figure 3).

TABLE 1. Mean tree performance data and competition levels for control vs. disc-trenched plots within C.P. 42 (Vanderhoof)

Parameter	Treatment		P Levels
	Control	Disc Trenched	
1985 diameter (mm)	3.0	3.2	n.s.
1986 diameter (mm)	5.5	6.7	0.003
1987 diameter (mm)	8.5	10.8	0.007
Diameter increment 85/86 (mm)	2.5	3.5	0.003
Diameter increment 86/87 (mm)	2.9	4.1	0.038
1985 height (cm)	19.2	18.8	n.s.
1986 height (cm)	25.2	27.8	0.078
1987 height (cm)	38.8	44.2	0.130
Height increment 85/86 (cm)	6.0	9.2	0.004
Height increment 86/87 (cm)	13.5	16.3	n.s.
1986 Competition Index *	330	258	0.242
1987 Competition Index *	229	164	0.135

P levels indicate significance of difference between control and disc-trenched sites; n.s. indicates $P > 0.20$.

* Competition Index is an index of light competition and is calculated for each non-crop vegetation species (within a 1.26 radius crop tree centered plot) which covers > 10% of the plot and is greater than half the height of the seedling. The index is calculated using the following formula: $\sum C_j \times Vh_j / av_j$ where C_j = % cover of species j, Vh_j = height of species j, and av_j = average distance to the inner edge of foliage of species j from the center of the crop tree.

TABLE 2. Some free-to-grow establishment cost projections (¢/tree)

Cost Element	No M.S.P.	Trenched	Broadcast Burn
Nursery cost	14¢	14¢	14¢
Site prep.	0	7¢	14¢
Planting	30¢	25¢	25¢
Surveys and maintenance	5¢	2¢	2¢
Total Cost/Tree	49¢/tree	48¢/tree	55¢/tree

Vanderhoof Site (C.P. 42)
Disc-trenched vs. control

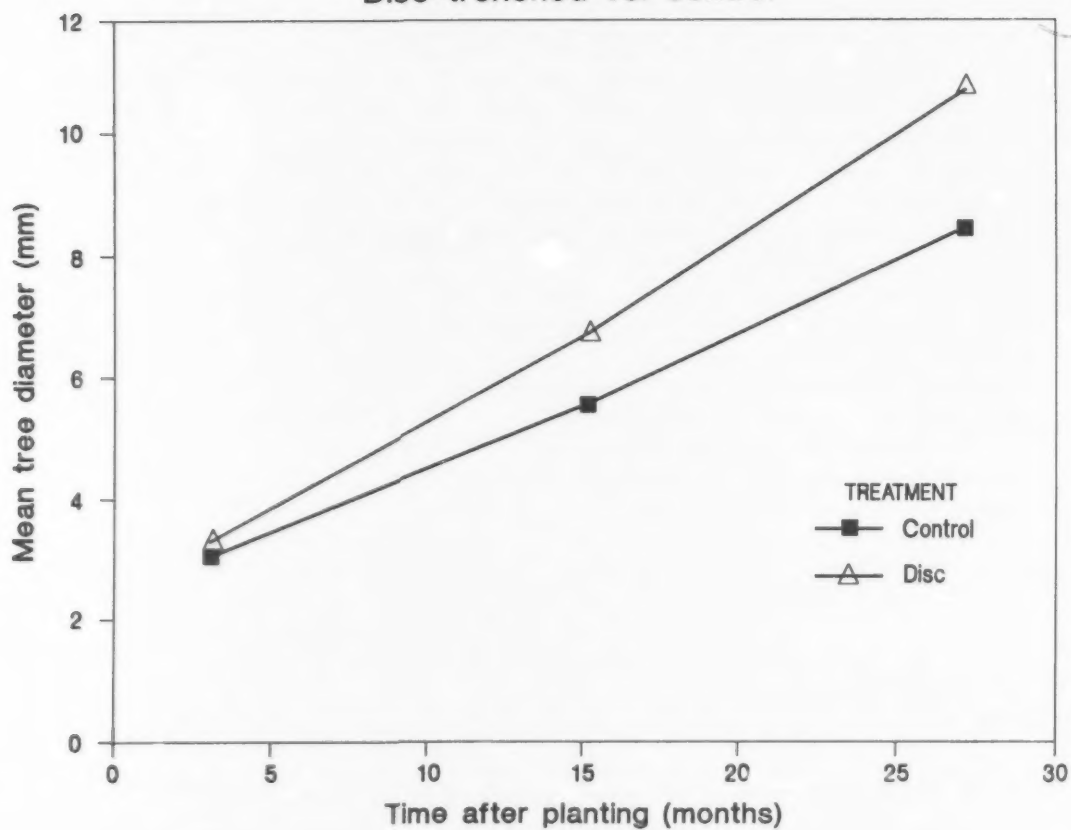


FIGURE 3. Mean tree diameter (mm). (Unpublished data from C. DeLong, B.C. Ministry of Forests, Prince George, B.C.)

Disc trenching does several things to increase seedling growth and survival:

1. aerates the soil;
2. mixes organic material and mineral soil, which increases cation exchange capacity and water retention properties;
3. peels away any competing vegetation to increase moisture, sunlight and nutrient availability;
4. exposes soil to the sun for increased soil temperatures;
5. loosens soil for easier root penetration, especially where compact layers or fine-textured soils occur;
6. reduces incidence of attack by pine root collar weevil (they avoid exposed mineral soil); and
7. provides good microsites for precocious seeding.

A 1987 visit to a 1974 trenched site revealed that the soil in the trenches was still much looser than where it was undisturbed. Long-term advantages provided to a seedling by loosening the soil are considerable.

Recently there has been concern expressed about root malformation because of the potential for plantation toppling. Several trenched sites reviewed over the past year showed no major problems. The root systems of trees in the trenches are, however, more extensive than those outside the trenches.

FUTURE USE OF DISC TRENCHING

In the past I have prescribed trenching for sites with light-to-moderate slash loadings and a threat of vegetative competition which is likely to reduce the ability of a plantation to easily achieve free-to-grow. On these sites the slash loadings are not heavy enough to require broadcast burning. Most of the sites which have fallen into this category in the past have been mesic pine sites. However, we are using the trenchers on increasingly tougher sites every year, and with the advent of the V-rake, on sites with increasingly heavier slash loadings and deeper duff layers. This has prompted use of the TTS-35 Delta powered trencher which has hydraulic-driven discs. This model is lighter and more easily transported since it is mounted directly on the skidder. It provides a better-defined trench profile with consistently good results when combined with the V-rake, thus allowing us to trench areas with even heavier slash loadings and deeper duff depths than with the passive model. Indeed, these are sites which we may have considered for broadcast burning or piling and burning in previous years. We'll have to watch the results of this machine closely, particularly on steep slopes and fine-textured soils, and perhaps even make the trenches intermittent to avoid potential problems such as erosion or root malformation.

Mechanical Site Preparation Options in North Central British Columbia

by
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The value of elevated planting spots for increasing soil temperature and improving drainage and aeration around seedling roots has been established from operational experience, data from comparative trials and ecophysiological research in both Canada and Fennoscandia. The types of raised planting spots which can be formed by mechanical site preparation are outlined below. Raised planting spots can be formed as mounds or as interrupted or continuous ridges, berms or tilts, depending on the terminology preferred. While all improve soil temperature and drainage, their effectiveness in providing adequate soil water, vegetation control, light and nutrients depends on the site.

TYPES OF ELEVATED PLANTING SPOTS

Mineral Soil on Inverted Humus (Inverted Humus Mounds)

Raised planting spots consisting of mineral soil on inverted humus are biologically favourable because soil temperature is elevated, root growth is improved and seedling nitrogen levels are enhanced by the second growing season. Vegetation is controlled when the mineral soil capping is sufficiently deep. Inverted humus mounds are suitable for fine-textured soils because seedling roots can grow in the friable medium at the mineral soil/inverted humus interface where the soil is warm and nitrogen is available from the inverted humus.

Mineral soil cappings must be deep enough for optimum results. For example, on a fertile, subhygric site, 14 cm mineral soil cappings were found to be deep enough. Cappings which were 20 cm deep provide no additional improvement. Six centimetre cappings gave less favourable growth, and mounds with 1 cm cappings were no better than no treatment. Scarified patches were waterlogged, resulting in high mortality and frost heaving.

Frost damage during the growing season may be mitigated by planting seedlings in exposed mineral soil. Plowing, a form of mineral-covered inverted humus, can reduce growing season frost damage and improve seedling growth rates in the manner commonly found on raised, mineral-capped inverted humus planting spots.

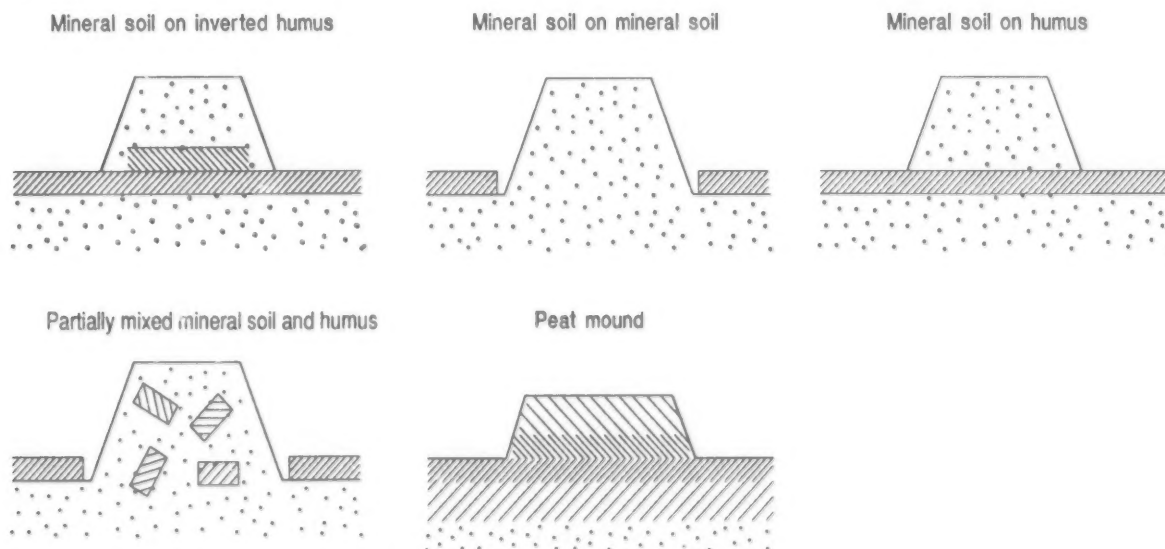


FIGURE 1. Types of elevated planting spots.

Standard-length plugs planted normally (to the root collar) in mounds with deep mineral soil cappings are not long enough to reach the moisture beneath the duff. Moisture accumulates there because control of competing vegetation reduces water usage by transpiration and the duff causes capillary discontinuity, which interrupts the upward movement of soil moisture, trapping it below the duff. Seedlings planted J-rooted within the mineral soil cap also do not reach the continuous supply of moisture beneath the duff. Deprived of soil moisture during drought periods, such seedlings may die or become stunted by drought.

An alternative with standard-length seedlings is to plant them deeply enough to reach the moisture beneath the duff, even though their needles may be partly buried. Another alternative is to use long-rooted seedlings, such as PSB 323, which have 23-cm-long root systems. Even planted at normal depth, such seedlings could reach the moisture beneath the duff. A test of PSB 323 seedlings on mounds of two different sizes is planned for 1988.

Mineral Soil on Mineral Soil

Raised mineral soil planting spots on mineral soil have been found to be favourable for seedling growth even where lack of soil moisture may be a problem. Capillarity helps to maintain soil moisture because there is no discontinuity at the base of the elevated planting spot. Nitrogen in the surrounding humus layer can be reached by seedling root growth enhanced by increased soil temperature if soil texture is not so heavy that root penetration is inhibited.

Mineral Soil on Humus

Mounds of mineral soil dropped on otherwise undisturbed humus have been used extensively in Finland when the spoil from drainage ditches provides raised planting spots on wet sites. About 30 L of mineral soil is recommended to help compact logging residues, vegetation and duff so as to reduce undesirable looseness and to help establish capillary continuity. Vegetation is controlled by the mineral cap. Drying out can be mitigated by planting the roots of bareroot transplants into the underlying humus layer. Nitrogen becomes available as the original humus layer decomposes, although seedlings may be chlorotic during the first season before the humus starts to decompose.

Mixed Mineral Soil and Humus

Raised planting spots consisting of mixed mineral soil and humus elevate soil temperature, avoid capillary discontinuity, improve aeration and provide access to the nutrients in the mixed duff. On sites where competing vegetation is not a problem, such elevated planting spots have been found to be favourable. However, unless mixing chops weed roots into sufficiently small pieces that they do not readily resprout, mixed mineral and humus ridges may sprout luxuriant weeds. Mixing as completely as possible (as with a Madge Rotoclear) can control competing vegetation, and the mixed soil can be bedded to form a raised ridge.

Peat Mounds and Ridges

Digging out peat to form mounds or ridges may be the only way to increase soil temperature, improve drainage and control competing vegetation in deep peat soils. The initial chlorotic appearance of seedlings suggests that the nutrient status of raised peat may initially be less than ideal. However, as the peat mineralizes, seedling colour improves. Desiccation is a problem which may be overcome by deep planting long-rooted seedlings.

CAPABILITIES OF SITE PREPARATION MACHINES

Different sites can be prepared by different machines or prepared appropriately by a single machine capable of different types of site preparation. Site-specific treatment is facilitated in British Columbia by the biogeoclimatic ecosystem classification system.

Increasingly, equipment manufacturers are developing multifunctional machines rather than machines that can prepare only one type of planting spot.

Excavators can cope with slash, steep slopes and wet ground and can form all types of raised planting spots as well as exposed mineral patches. Operating costs, however, are relatively high because excavators may average only 0.2 ha/hr when forming patches and only 0.1 ha/hr when mounding.

Bräcke Mounders can form mineral patches, mineral mounds, inverted humus mounds and peat mounds. The mineral soil capping formed may not be deep enough to be optimal on hygric or weedy sites.

Donaren 870H and BCFS Mounders can form scarified patches, inverted humus and peat mounds, but their single-stage scooping action does not lend itself to making mineral-on-mineral soil mounds.

Donaren 180D, 280 and TTS Delta Disc Trenchers (with optional intermittent function) can form scarified patches or continuous furrows as well as partially mixed mineral soil/humus berms. Such partially mixed berms, however, may encourage rather than suppress competing vegetation.

Wadell Cone Trenchers form exposed mineral soil patches or trenches and small partially mixed mineral/humus mounds. Aggressive competing vegetation may not be controlled by such partially mixed mounds.

CONCLUSION

This synopsis of what can be expected from different types of elevated planting spots is based on data from comparative trials and best estimates. Many more seedling growth data from comparative trials on different sites are needed before we can have confidence in the capabilities of different machines to give the biological results wanted on each different site.

Site Preparation Options for Improving Plantation Performance in Low-precipitation Areas of the Cariboo Region (E.P. 841.06)

by
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Planting of Douglas-fir has generally not been successful in the IDfb and drier subzones of the SBS (SBSa, SBSb, SBSk) of the Cariboo Region. The average survival of Douglas-fir plantations has been estimated at 77% for 1984 and 50% for 1985 (Sutherland, unpublished data). Evidence from several trials and operational plantations suggests that this unacceptably poor performance can be attributed to two factors: seedling moisture stress, and poor quality stock. Each single factor reduces seedling survival and growth, and the combination of both worsens performance.

A trial was established in 1985 to test the hypotheses that:

1. various types of soil treatment designed to relieve soil moisture stress have no effect on seedling performance, whether the seedlings are "normal" quality Douglas-fir, lodgepole pine or spruce; and
2. this lack of effect is found in both the IDfb and SBSk subzones.

METHOD

Site Selection

Two sites were selected within each of the subzones chosen for study (Coupé and Yee 1982). Within the IDfb subzone sites were backlog areas with a well-developed cover of pinegrass, and with little prospect of additional natural regeneration (Em-Fire and Axe Lake). The sites chosen in the SBSk subzone were logged in 1980, requiring planting, but had not been slash burned. They had a well-developed cover of herbs, grasses and low shrubs (Beedy Creek and Sheridan Creek).

The IDfb ecosystem units were IDfb2/01 - Pinegrass - Twinflower, mesic, loam-textured Luvisol over till with elevations of 1150 m. The SBSk ecosystem units were SBSk1/01 - Falsebox - Sarsaparilla, sandy loam or silt loam Luvisols over washed till with elevation of 910 to 980 m.

Site Preparation Treatments

Seven site preparation treatments, chosen either to remove competing ground vegetation and/or to loosen the upper soil horizons, were tested for possible effects on seedling performance in both subzones in the summer and fall of 1984:

1. control (no site preparation);
2. hand screef (30 x 30 cm removal of humus);
3. Leno patch scarifier (50 x 100 cm removal of humus);
4. MM disc trencher (a continuous 50 cm wide removal of humus and mineral soil);
5. ripper teeth (up to 80 cm vertical soil disturbance);
6. ripper-plow (up to 80 cm vertical soil disturbance and 50 cm wide humus removal); and
7. V-plow (2.5-3 m wide humus and soil removal — SBSk sites only).

Planting Stock Treatments

Douglas-fir and lodgepole pine were outplanted in the spring of 1985 on all four sites, and Interior spruce was planted on the two sites in the SBSk subzone. All stock was tested for root growth capacity and proved to be healthy and capable of growing roots (I.R.G. = 3+).

Measurement and Analysis

Seedlings were measured at one, two, and three years after planting for survival, condition, height and root collar diameter. Vegetation cover was also measured at planting and after one, two and three years. Data from Axe Lake and Sheridan Creek were not analysed because heavy cattle damage biased the results.

CONCLUSIONS

A) IDfb (Em-Fire)

- i) Douglas-fir — Seedling survival has increased with an increase in soil disturbance by treatment (Figure 1). Survival for all treatments, however, was below acceptable levels of 75%. Seedling height growth has been minimal for most treatments (Figure 2), as has seedling diameter growth (Figure 3). Best results were achieved using the treatment which produced the greatest soil disturbance (ripper-plow).
- ii) Lodgepole pine — Seedling survival has increased with the addition of a continuous furrow. Acceptable survival levels were achieved with every treatment except the control (Figure 4). Seedling height growth has significantly increased with the addition of a continuous furrow and also increased with the addition of vertical ripping (Figure 5); the same applies for seedling diameter growth (Figure 6). Best third year survival and growth results were achieved using any treatment which produced a continuous furrow (trencher, ripper and ripper-plow).

Lodgepole pine survival and growth was much better than Douglas-fir across the range of site preparation treatments.

B) SBSk (Beedy Creek)

- i) Douglas-fir — Seedling survival has increased with an increase in soil disturbance and has shown three distinct survival groups. Survival was only acceptable for the ripper-plow and V-plow treatments (Figure 7). Seedling height growth has been minimal and has shown no significant differences between site preparation treatments (Figure 8), as has seedling diameter growth for most treatments (Figure 9). Best third year survival and growth results were again achieved using those treatments which produced greatest soil disturbance (ripper-plow and V-plow).
- ii) Lodgepole pine — Seedling survival has been maintained at over 90% for all soil disturbance treatments. Survival was acceptable for all treatments except the control (Figure 10). Seedling height growth has responded well to all treatments except the control (Figure 11). Seedling diameter growth has also responded well but was not significantly different between all treatments (Figure 12). Best third year survival and growth results were achieved using any type of mechanical treatment (Leno, trencher, ripper-plow and V-plow).
- iii) Interior spruce — Seedling survival has been maintained at over 85% for all soil disturbance treatments. Survival was acceptable for all treatments except the control (Figure 13). Seedling height growth has been minimal (Figure 14). Seedling diameter growth has responded well but was not significantly different between all treatments (Figure 15). Again, best third year results were achieved using any type of mechanical site preparation.

Lodgepole pine and spruce both had better survival than Douglas-fir. Lodgepole pine grew better than spruce across the range of treatments.

C) Frost Damage

When this trial was established frost damage was not considered to be a significant mortality factor. However, after three growing seasons the occurrence of frost and frost damage have both been identified. Frost can occur during every month of the growing season. Frost damage is present on both the Em-Fire and

Beedy Creek sites. The damage was highest for Douglas-fir (25-50%). The second highest damage occurred on Interior spruce (16%), and frost minimally affected lodgepole pine (4%). Frost damage cannot be assigned to site preparation treatment since this factor was not properly monitored.

SUMMARY

Early results suggest that more intensive soil disturbance is required to achieve acceptable survival and growth of Douglas-fir, lodgepole pine and Interior spruce in the IDfb and SBSk subzones.

More soil disturbance is needed in the IDfb subzone than the SBSk subzone. This may indicate that additional soil exposure and soil loosening can offset the increased environmental stresses in the IDfb.

Early results also suggest that lodgepole pine is out-performing both Douglas-fir and spruce on these drier sites, across the range of site preparation treatments.

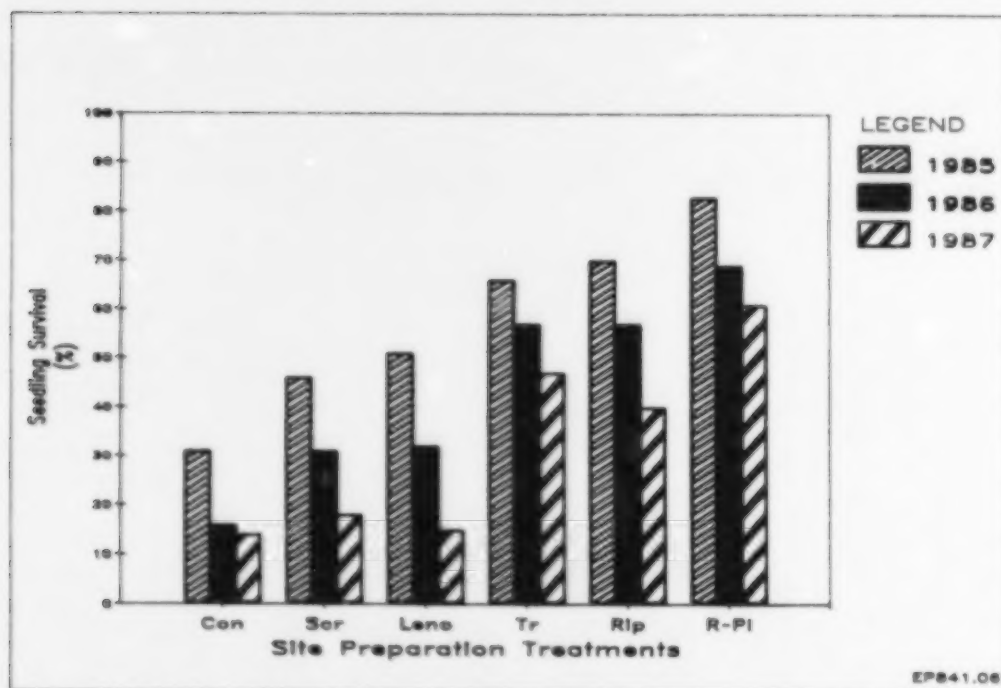


FIGURE 1. Douglas-fir seedling survival, Em-Fire (IDfb).

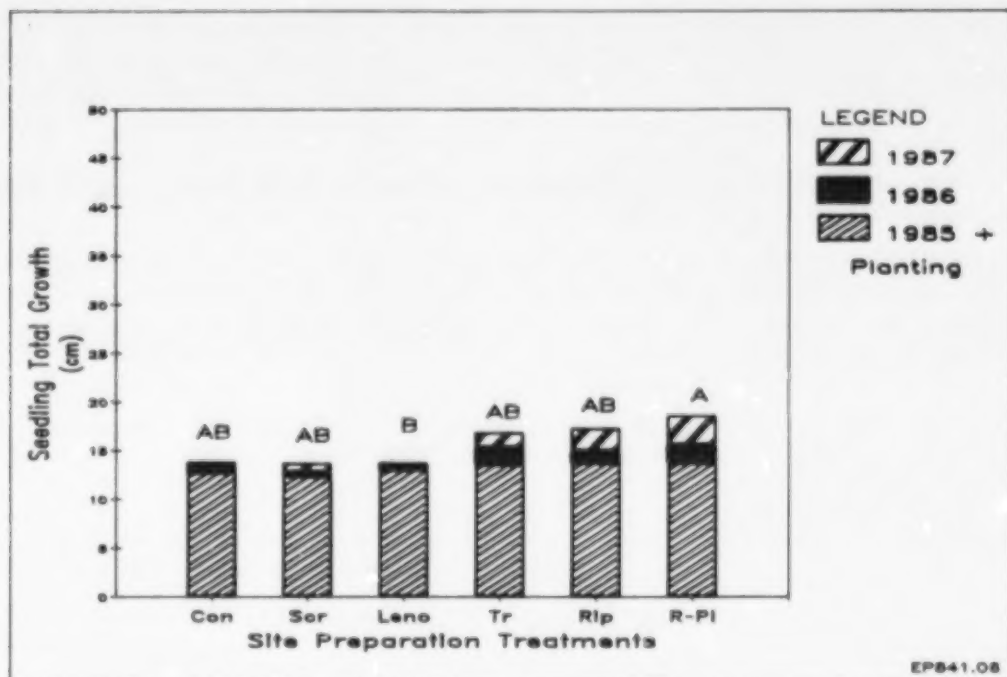


FIGURE 2. Douglas-fir seedling height growth, Em-Fire (IDFb).

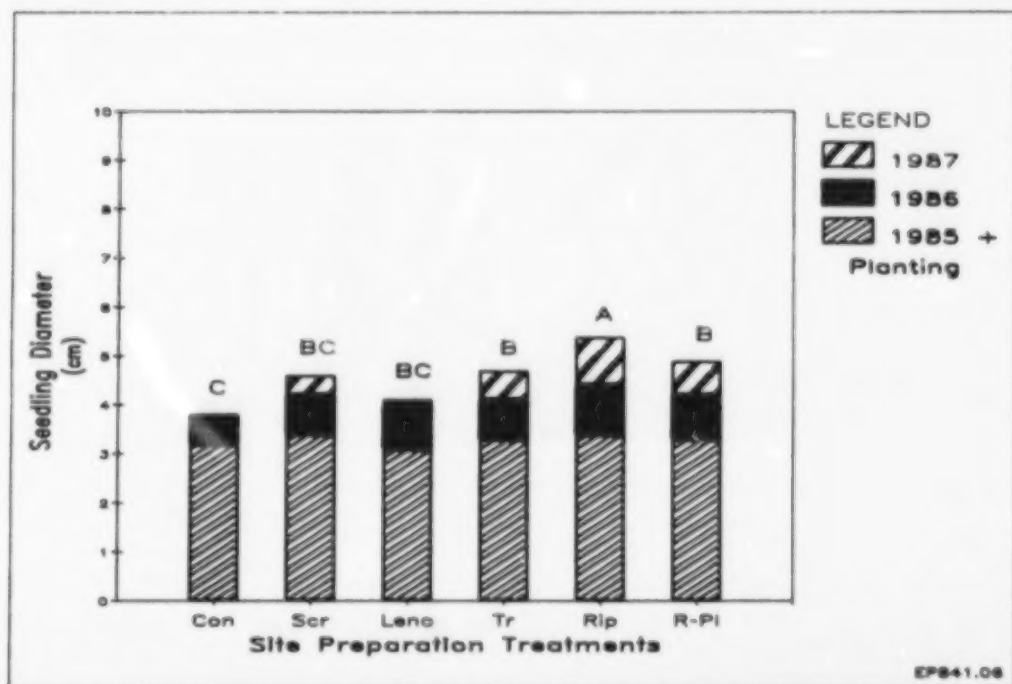


FIGURE 3. Douglas-fir seedling diameter growth, Em-Fire (IDFb).

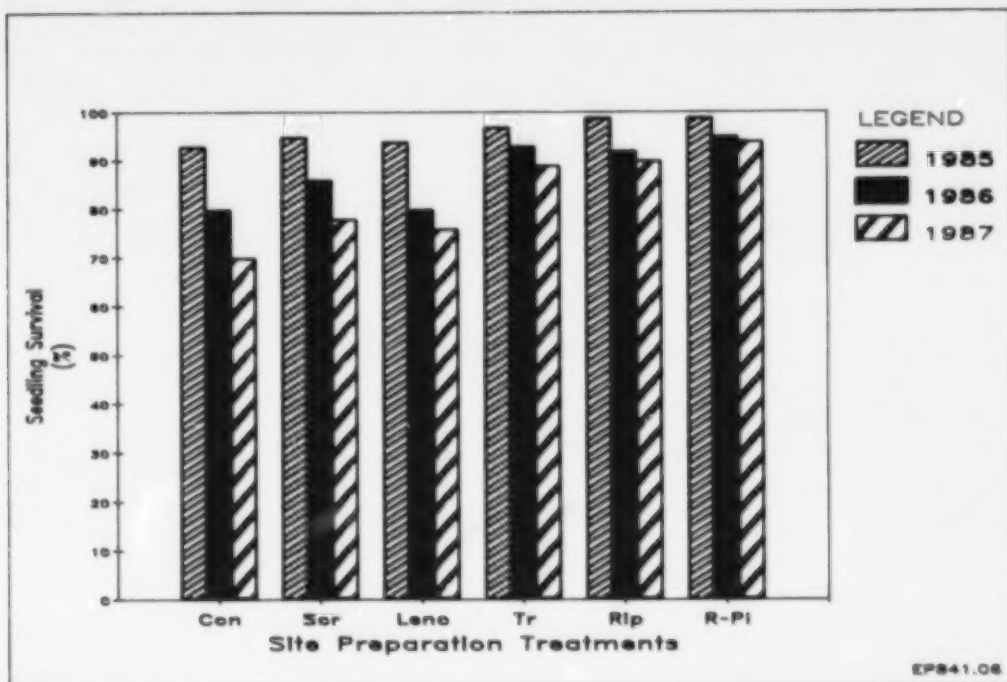


FIGURE 4. Lodgepole pine seedling survival, Em-Fire (IDFb).

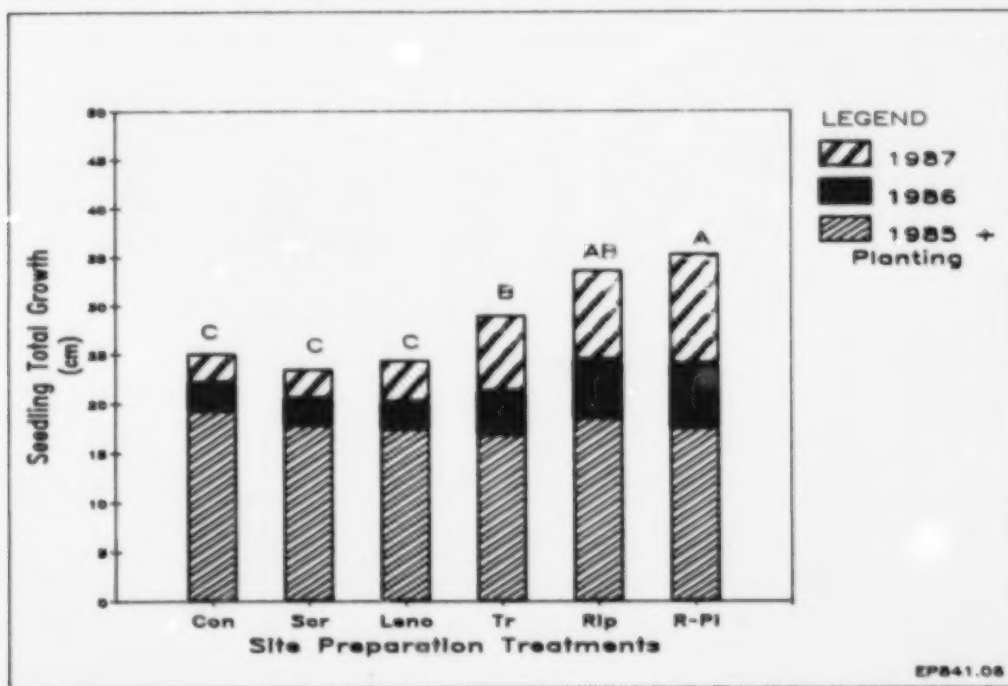


FIGURE 5. Lodgepole pine seedling height growth, Em-Fire (IDFb).

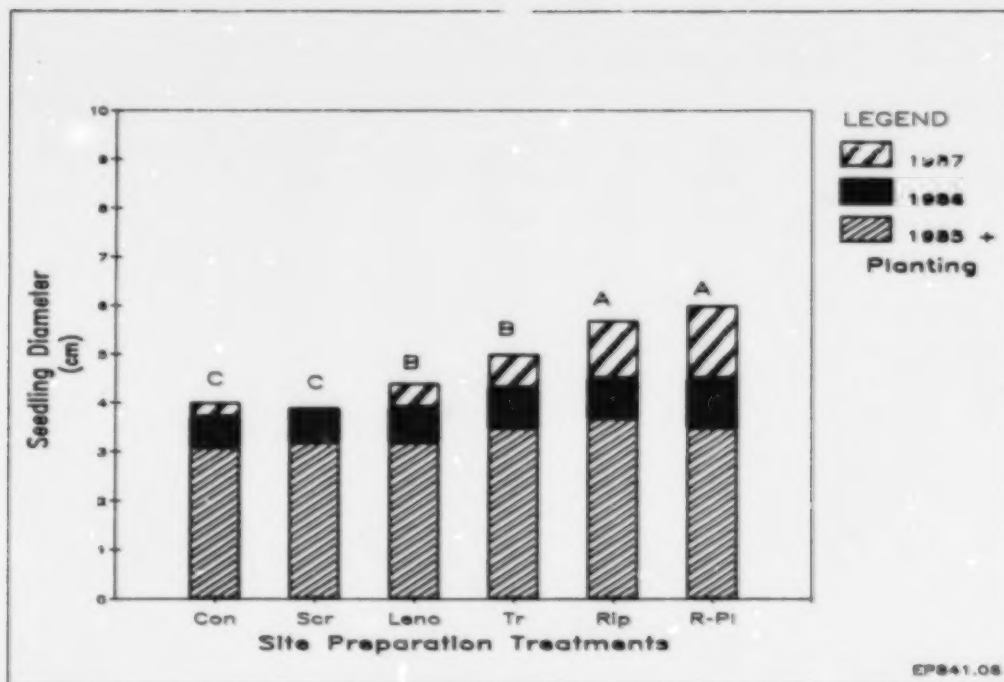


FIGURE 6. Lodgepole pine seedling diameter growth, Em-Fire (IDFb).

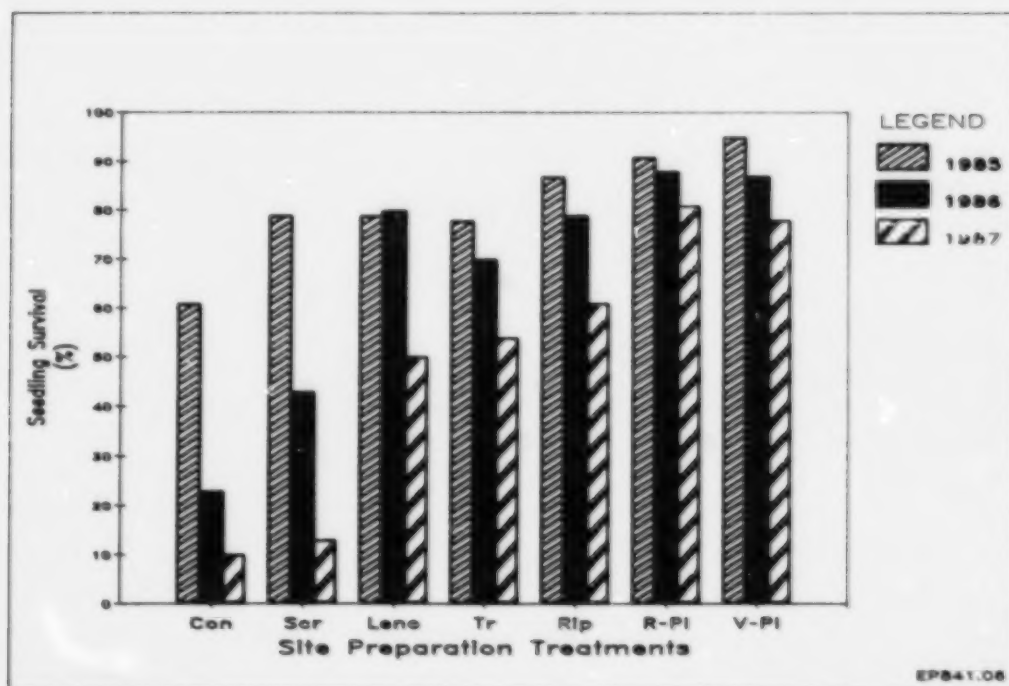


FIGURE 7. Douglas-fir seedling survival, Beedy Creek (SBSk).

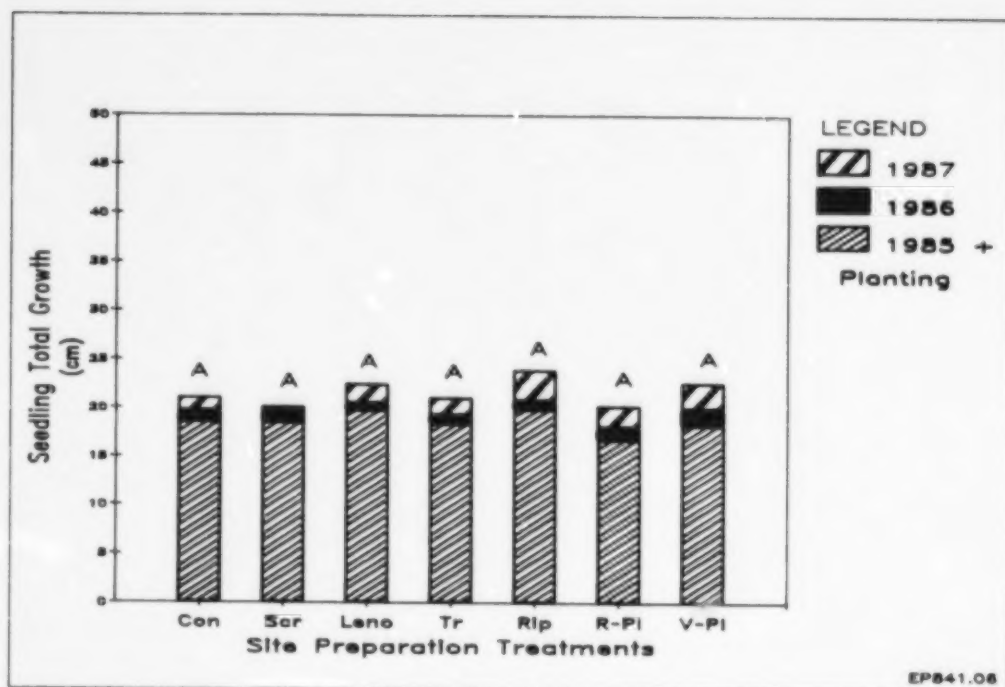


FIGURE 8. Douglas-fir seedling height growth, Beedy Creek (SBSk).

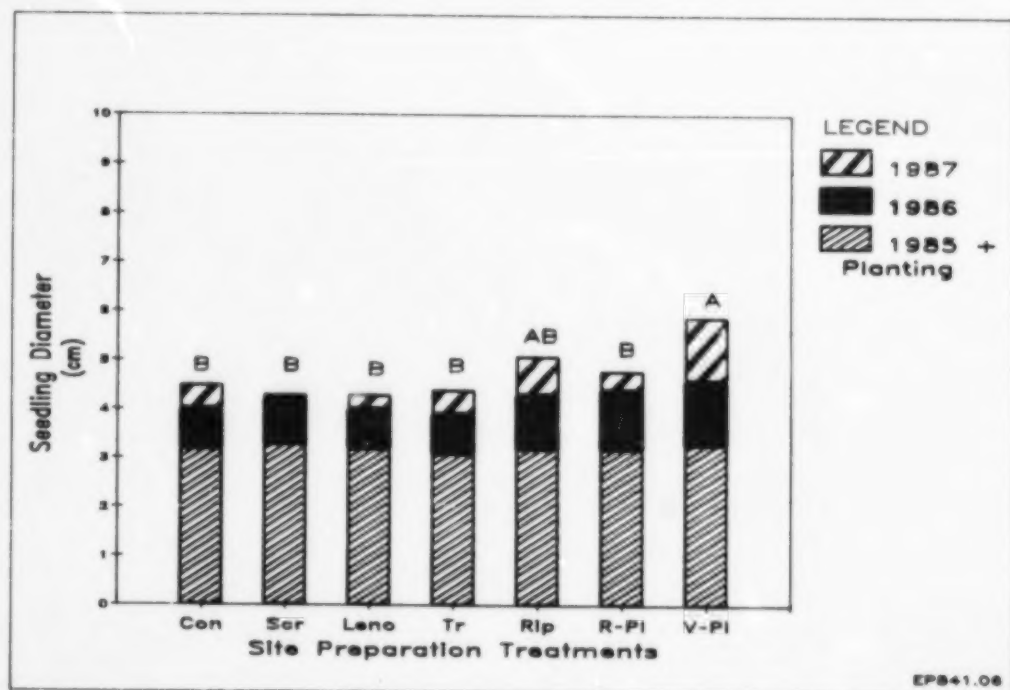


FIGURE 9. Douglas-fir seedling diameter growth, Beedy Creek (SBSk).

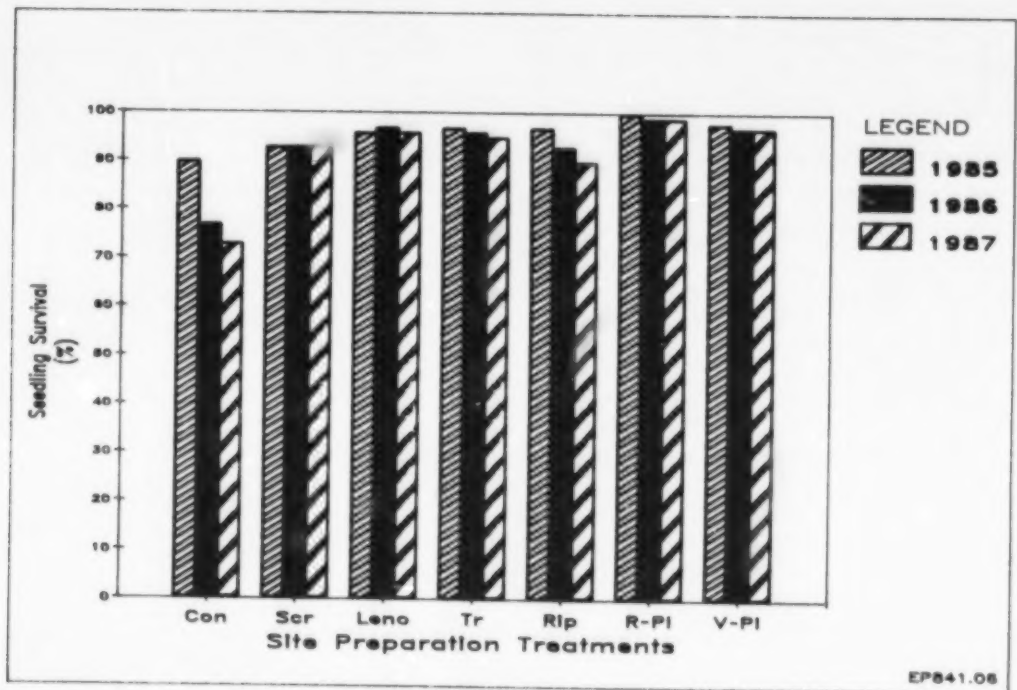


FIGURE 10. Lodgepole pine seedling survival, Beedy Creek (SBSk).

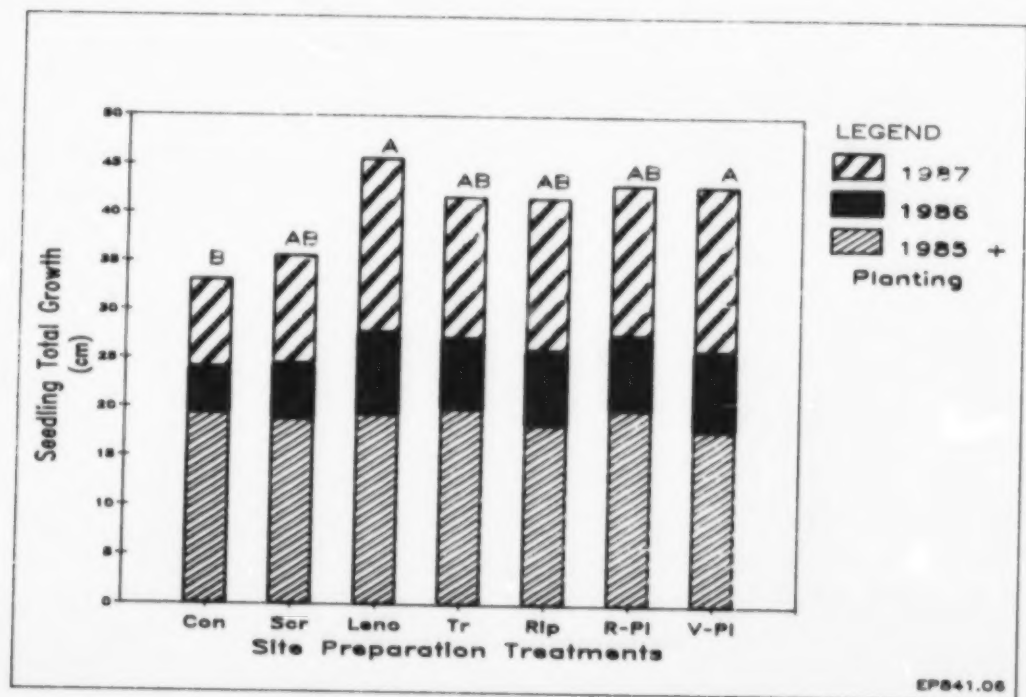


FIGURE 11. Lodgepole pine seedling height growth, Beedy Creek (SBSk).

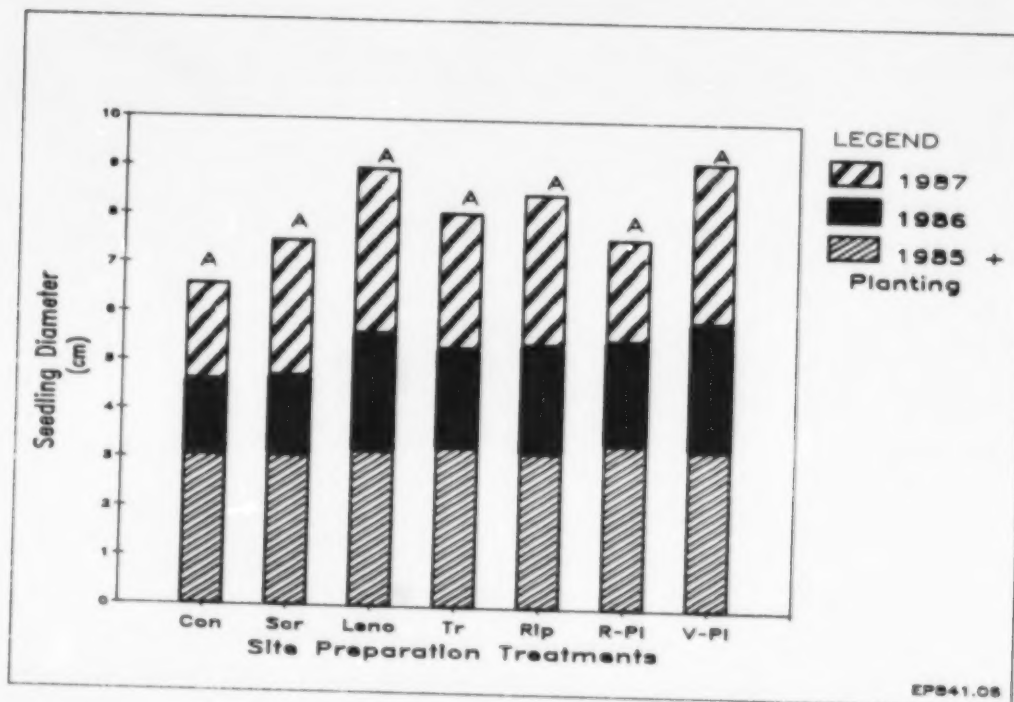


FIGURE 12. Lodgepole pine seedling diameter growth, Beedy Creek (SBSk).

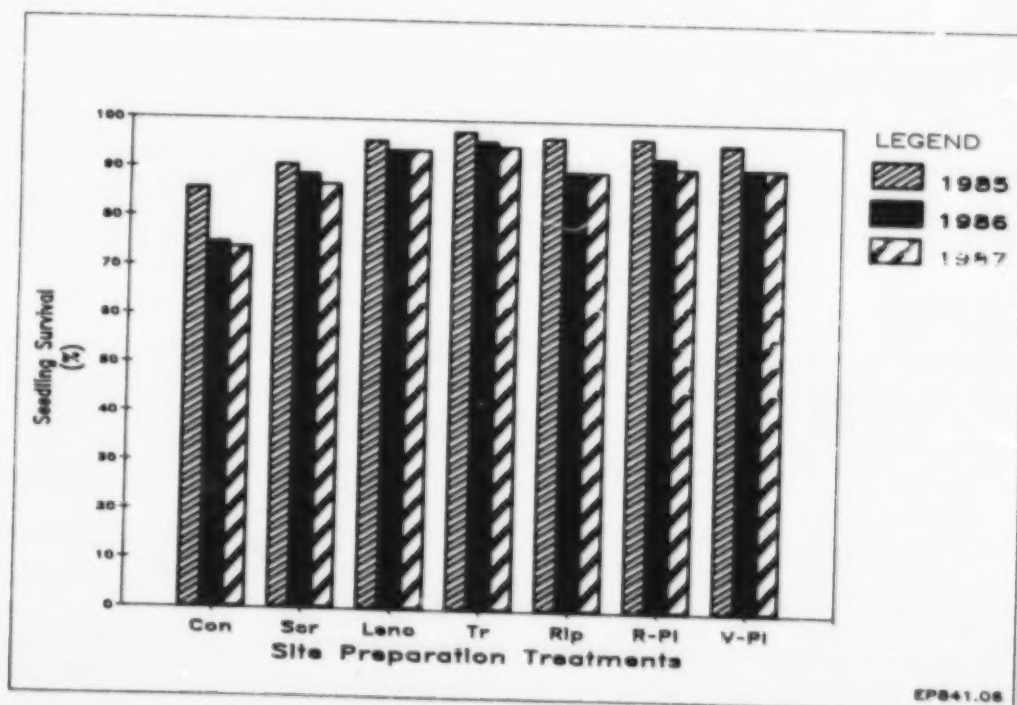


FIGURE 13. Interior spruce seedling survival, Beedy Creek (SBSk).

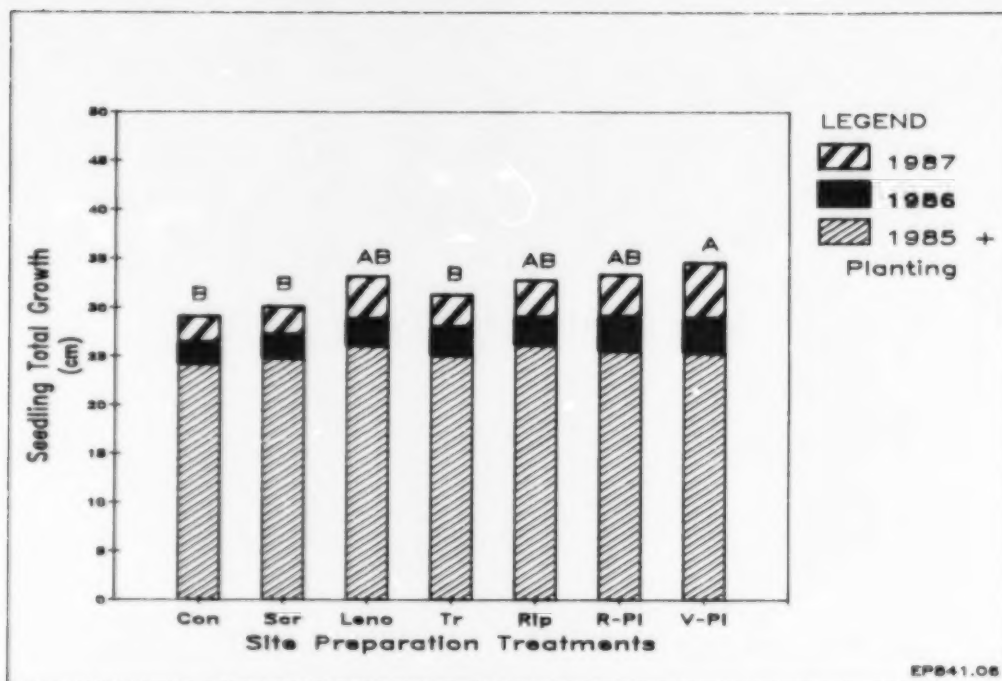


FIGURE 14. Interior spruce seedling height growth, Beedy Creek (SBSk).

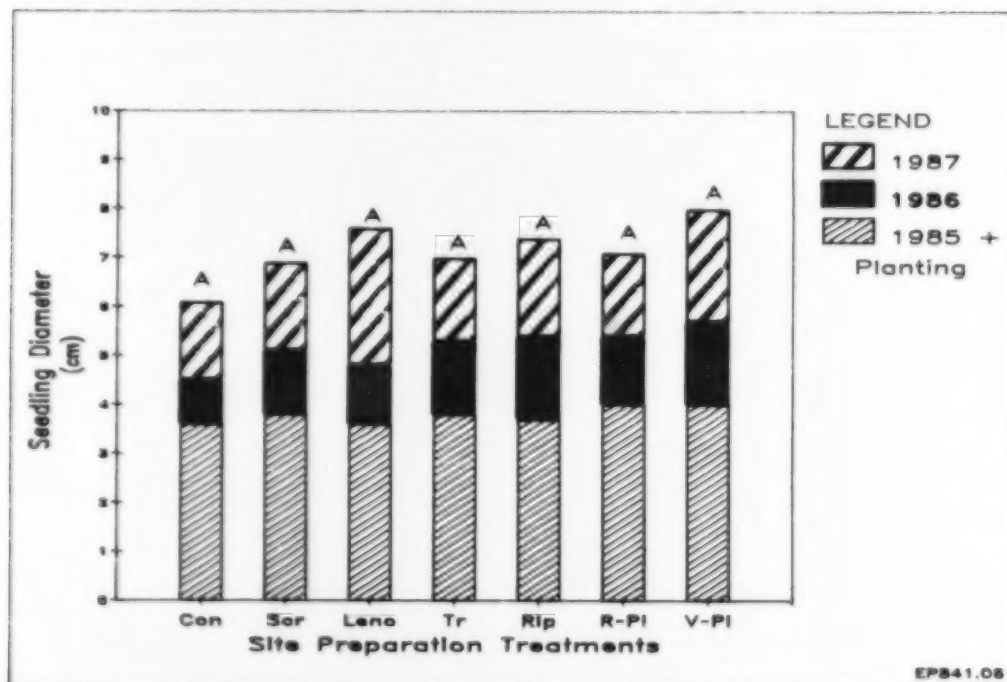


FIGURE 15. Interior spruce seedling diameter growth, Beedy Creek (SBSk).

Site Preparation and Aspen Control in the SBS

by
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Canadian Forest Products Ltd. Prince George woodlands operations comprise two divisions: Isle Pierre (SBSk3, k2 and e1 subzones) and Fort St. James (SBSk3, e2, e1, d and n subzones). Most problems with aspen occur in the SBS e2 and SBSk3 variants.

ASPEN - THE SPECIES

Trembling aspen (*Populus tremuloides*) occurs throughout British Columbia east of the Coast Mountains, extending from valley bottoms to approximately 1200 m in the Interior. It can inhabit shallow, rocky soils, sandy loams and wet clays but is predominantly a species of well-drained uplands. Its dominant form of regeneration is through suckers that develop from the extensive root system. The majority occur within 10 m of the base. Initial growth of 1 m/year in height is typical.

Trees cut or damaged during logging will produce prolific suckers, and even those remaining undamaged are stimulated into production by increased light and heat. Site preparation techniques such as drag scarification and disc trenching also increase suckering due to increased light and temperature. Increased soil temperatures caused by burning stimulate suckering, although light-intensity burns produce fewer stems than moderate- to high-intensity burns. In essence, all of the normal activities associated with logging and post-logging site preparation stimulate suckering.

CONTROL METHODS - PHILOSOPHY

Prevention

We prevent aspen suckering by controlling the number of live mature stems that remain at harvest. In theory, aspen stems killed by herbicides in a mature stand will not sucker if the root reserves have been depleted prior to harvest. We identify those clearcuts having significant aspen components and chemically treat them, preferably three years ahead of harvest.

Stocking First

We stock areas either artificially or naturally and resolve any further aspen problems that may arise later. Any mature aspen still standing after harvest is knocked down during site treatment to ensure that any suckers will show early.

ASPEN PROBLEMS

Minor Aspen Components

Where cruise data show an average of 15 aspen stems/ha or less, we do not carry out any pre-harvest treatments. Harvest and site preparation are carried out. If the area requires artificial regeneration immediately, this takes place, or establishment of naturals begins. Two or three growing seasons later, any aspen problem is tackled. The delay allows complete expression of suckering, and identification of areas requiring treatment.

Major Aspen Components

Major aspen components are those areas with more than 15 aspen stems/ha. Such areas are chemically treated with pre-log hack-and-squirt with glyphosate. Harvest will not commence until at least three growing seasons following treatment. Often, areas planned for logging that far ahead have not been cruised, in which case we carry out aerial reconnaissance of the Development Plan Blocks.

Often, a block scheduled for harvest three to four years ahead must be harvested early, which could result in a major aspen problem. We could log it without pre-treatment, or carry out pre-treatment in a shorter time frame by using hexazinone. We have no experience of the latter but propose to treat 389 ha using this method in May 1988. Hexazinone will be applied by ground spot treatment around deciduous stems, which should allow harvest to commence within 1.5 growing seasons. Both pre-log hack-and-squirt and pre-log hexazinone will be site-prepared in the normal manner. Any further brushing and weeding needed will be scheduled two years after site preparation or planting.

Some blocks slip through pre-treatment and have a major aspen (or birch/cottonwood) component. Options here include a hexazinone ground spot treatment after logging, with normal site preparation delayed to the following summer/fall — in other words, post-log hexazinone in May 1987 and complete site preparation in summer/fall 1988. Normally, stocking establishment will follow. Any further brushing or weeding needed would follow two to three years after site preparation. The other option is to accept that aspen will sucker vigorously, apply for a herbicide permit, and plan to brush and weed two years following site preparation.

Backlog Stands

Backlog stands are areas harvested and site prepared prior to registration of glyphosate and hexazinone. These stands range from five to 17 years of age. Most are stocked or overstocked with lodgepole pine; some are NSR or partially NSR; but all have aspen overtopping all or parts of the clearcut block.

In 1985 we chemically treated with hexazinone a number of blocks in close proximity to each other and adjacent to one main road system. The ages, sites and densities of regeneration were all different. Some blocks were freshly logged with no site preparation.

On freshly logged sites in 1986 we carried out split chemical treatments using a post-log hack-and-squirt with glyphosate, and a ground spot treatment with hexazinone. Site preparation occurred in summer/fall 1987. The other stands were treated with ground-spot hexazinone and one with brushsaw and glyphosate.

Our other options to control aspen in backlog stands are either aerial spraying or combinations of mechanical/chemical treatments such as the Bräcke Herbicider.

Options for treatment are summarized schematically in Figure 1.

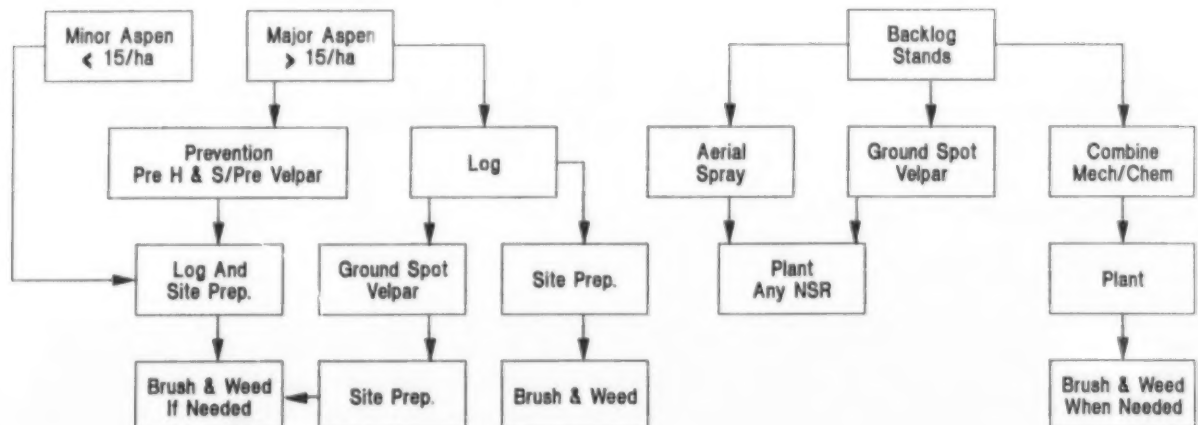


FIGURE 1. Flow diagram for aspen control.

SUMMARY

Pre-Log Hack-and-Squirt

- 1) **Timing.** Original theory is to apply in late July/August, such that translocation is down into the roots via the phloem. This kills the roots and eventually the tree. In 1987 we applied early in July/August on most blocks. We injected into the xylem rather than the phloem, which then translocates up into the crown, killing the top. This starves the tree to death over three to four growing seasons.
- 2) **Assessment.** Assessment prior to harvesting is essential. An example of post-harvest assessment of a block treated pre-harvest with glyphosate hack-and-squirt is given in Table 1.
- 3) **Ground Control.** Assessment revealed that operators were missing trees, especially in the aspen types where stems were scattered. This led us to tighten up ground control. Our objective is to ensure that 100% of targetted species are treated.
- 4) **Product Concentrations.** We have used a 50/50 concentration of product, varying the concentration in places to measure the impact.

Post-Log Hexazinone

- 1) **Timing.** The earlier the better, within reason. Our 1986 program went on in June/July, whereas the 1987 work was started in May. Much more kill was noticeable in the May application.
- 2) **Assessment.** Establish clearly marked photopoints and take chronological photorecords of changes in vegetation and tree growth. Trees will re-flush up to two to three times after application. Leaf sizes will vary, and health will perhaps appear different. Two to three growing seasons down the road the true result will show.
- 3) **Ground Control.** Block off the area into manageable units of known size. This allows the operator to continually monitor the application rate/ha by visually estimating volume applied over a set distance (or area).
- 4) **Product Concentrations.** We apply pure product, normally on a 2 m x 2 m grid of spot applications, approximately 5.0-5.5 ml per spot. This translates to 12.5 L-13.5 L/ha. Obviously, soil types, duff thickness and brush concentrations will vary, as will application rates. We have tried strip applications in small amounts, which is certainly faster if brush density or height allow. There are some disadvantages to this method: ensuring that areas are not treated twice through overlap, or the reverse resulting in pieces being missed.
- 5) **Equipment.** Filling setups with double containers to catch spills are essential. Commercial Packs for 4 L jugs are handy; they can be worn on each hip and around back, depending on the length of run. CP 3 and wand is suitable for areas with little duff, or where strip application is feasible. A custom spear on a Phillips spot gun for a one-handed operation allows the operator to use the other hand for climbing over or through brush.
- 6) **Controls.** Many are essential — 50 m x 50 m is fine — put where they are obvious to the public. On NSR blocks, treated with hexazinone, that will be planted, plant up the controls even if you know they will not make it, or grow slowly at best. They have great visual impact and, other than photos, are the only record of what would have happened over the whole block without chemical treatment.

TABLE 1. Assessment of stem status classes following pre-harvest hack-and-squirt with glyphosate

Categories	Aspen Minor		Aspen Major	
	% Stems	0.95 ha Stems/ha	% Stems	0.22 ha Stems/ha
Dead treated	72.8	33.7	94.4	304.5
Partially dead treated	9.1	4.1	1.3	3.4
Live treated	4.5	2.1	0.0	0.0
Untreated	13.6	6.3	4.2	13.6

Total area treated = 33.2 ha

Sample taken 5 m on either side of transect lines.

Use of Herbicides for Site Preparation and Brushing and Weeding In the Sub-Boreal Spruce Zone — a Northwood Perspective

by
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Interference from woody and herbaceous weed species is a major deterrent to growth and survival of coniferous tree seedlings in the Sub-Boreal Spruce Zone (McMinn 1982). Weeds compete with crop trees for scarce site resources, modify the seedling microenvironment and contribute to snow press damage. Historically, blade scarification and broadcast burning have been used with good results to facilitate the establishment of planted and natural seedlings. In many cases, however, this exacerbated weed problems. For example, soil disturbance during mechanical site preparation enhanced suckering of trembling aspen and provided a good seedbed for airborne and buried weed seeds (Table 1). In other areas, particularly those moist, nutrient-rich sites of the SBSf subzone, these methods were not of sufficient intensity to provide effective weed control. Poor weed control combined with planting stock that was not of sufficient size and vigour to withstand intense brush competition has resulted in dismally low survival rates (Figure 1).

TABLE 1. Comparison of deciduous stocking before and after harvest. Cutting Permit 312 - Unit 2 - Grizzly Bear Creek. Logged summer 1977 - scarified 1977. Data are from a 1985 regeneration survey.

Deciduous Species	Stems per hectare	
	Pre-harvest	Post-harvest
Black cottonwood (<i>Populus balsamifera</i> ssp. <i>trichocarpa</i>)	0	550
Trembling aspen (<i>Populus tremuloides</i>)	8	3950
Paper birch (<i>Betula papyrifera</i>)	6	1070
Totals	14	5570

CHEMICAL WEED CONTROL

Chemical weed control is now being integrated into Northwood's silvicultural strategy to improve the growth and survival of regenerated areas. Operational use of herbicides began in 1985 with 818.7 ha being treated and has increased to 3918.6 ha treated in 1987 (Table 2).

CHEMICAL SITE PREPARATION

The main objective of chemical site preparation is to set back the interfering weed species long enough to allow planted conifers to achieve site dominance. For chemical site preparation to be successful the weed species should be highly susceptible to the proposed herbicide. Also, the timing of the treatment should maximize impact.

The application of an herbicide that does not control a broad range of weed species may result in the conversion of one weed problem for another. The maintenance of a light brush cover of non-competitive species along with the lack of soil disturbance associated with this technique can be beneficial, however, creating a seedbed that is unfavourable for the germination of airborne and buried weed species.

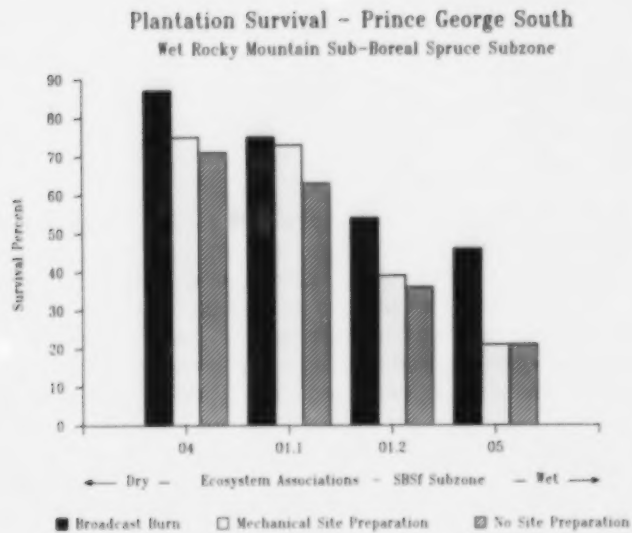


FIGURE 1. Survival of planted seedlings by site preparation method and ecosystem association. Site preparation alone does not provide sufficient brush control to ensure plantation success on the moist, nutrient-rich sites of the SBSf subzone. (data from Prince George South Operating Area)

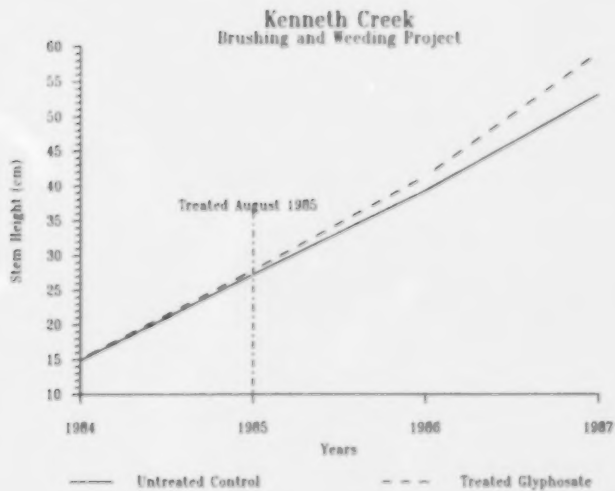


FIGURE 2. Height growth in untreated and glyphosate treated (2.14 kg/ha) white spruce seedlings. Planted August 1984 - PSB 2+0. (data from 1987 post stand tending survey)

TABLE 2. Summary of Northwood herbicide use, 1984-1987

Year	Licence	Herbicide	Application (Hectares)			
			Hack & Squirt	Aerial Release	Back Pack	Spot
1984	TFL 30 FL A16828	2,4-D MSMA	5.8 50 Trees			
1985	TFL 30 FL A18165 TSL A17834 FL A16828	Glyphosate Glyphosate Glyphosate Glyphosate	89.0 93.0 2894 Trees	442.7 73.0	36.0 85.0	
Total 1985 (ha)			182.0	515.7	121.0	
1986	TFL 30 FL A18165 FL 16828	Glyphosate Velpar L Glyphosate Velpar L	275.0	1049.3 371.0		27.1 29.0
Total 1986 (ha)			275.0	1420.3		56.1
1987	TFL 30 FL A18165 FL A16828	Glyphosate Glyphosate Velpar L Glyphosate	1500 trees	2346.6 793.0 291.2	90.0 338.0	59.8
Total 1987 (ha)				3430.8	428.0	59.8
Total to Date			462.8	5366.8	549.0	115.9

Chemical treatments do little to increase planter access, nor do they reduce the slash hazard. Therefore, chemical site preparation is best suited to areas of light slash. Per tree planting costs have been 30-100% higher on chemically treated areas than on equivalent broadcast burned or mechanically prepared areas. If there is a significant amount of advanced regeneration which can be preserved through the use of selective herbicides, these increased costs can be recovered through reduced seedling requirements.

BRUSHING AND WEEDING

Brushing and weeding selectively controls weed species that are reducing the survival and growth of newly established tree seedlings. The herbicide chosen should be effective in controlling the weed species, and brushing and weeding treatments should be timed to correspond to the period of both maximum crop tolerance and maximum herbicide effectiveness.

Chemical brushing and weeding is more efficient, safer and more economical than alternative manual methods. It offers lasting control and usually does not require a second treatment.

Herbicide treatments have much the same effect as fertilization treatments (Sutton 1969). The reduced competition for nutrients and the decomposition of above and below ground tissue of the killed plants result in a pulse of nutrients which the tree seedlings can exploit. Much of the benefit of brushing and weeding may derive from this fertility effect (Sutton 1975). Best results accrue from brushing and weeding when the tree still has the vigour to respond to the increased site resources (Miller 1985). Once suppressed, growth response is delayed while the tree restructures its roots and crown.

Early indications are that Northwood's brushing and weeding program has yielded significant increases in seedling growth and survival. In the Kenneth Creek area after two growing seasons, tree seedlings released by a herbicide when compared to untreated areas have exhibited modest increases in height growth (Figure 2) and larger increases in stem caliper (Figure 3), resulting in major increases in stem wood volume (Figure 4). The released seedlings are sturdier and have larger crowns.

WEEDS

Weed problems in the Sub-Boreal Spruce Zone are of two types. The first consists of the grasses, herbaceous and shrub brush species: fireweed, thimbleberry, red raspberry, black twinberry, lady fern, bracken, elderberry, trailing black currant and bluejoint. These weeds can cause serious problems within two years of site preparation and are most serious on the moist, nutrient-rich ecosystems of this zone.

The second category of weeds includes the hardwood tree species: trembling aspen, black cottonwood and paper birch. These species cause problems normally in the 5-10 year range and can occur on any ecosystem. These two brush problems may be combined forming formidable brush fields.

HERBICIDES

Hexazinone and glyphosate are good choices in the Sub-Boreal Spruce Zone. Glyphosate is a water-soluble foliar herbicide. It has been used for site preparation and release treatments using both aerial and ground application techniques. August applications at a rate of 6 L/ha have given good control of trembling aspen, black cottonwood, paper birch, Sitka alder, mountain alder, thimbleberry, black twinberry, lady fern, bracken and fireweed. Glyphosate has also controlled various grasses, provided they were sprayed prior to turning brown in late August. White spruce, lodgepole pine and Douglas-fir have excellent tolerance to glyphosate, provided it is applied after bud set.

Hexazinone is also a water-soluble herbicide. This herbicide is both a foliar and soil-active herbicide offering both contact and residual control. It is currently registered for both site preparation and release treatments using ground applications only. Experience with hexazinone on this zone has been mainly limited to concentrated spot applications. Using this method, 9-18 L/ha applied in the spring have provided good control of trembling aspen, black cottonwood, paper birch and grasses. Concentrated Velpar spots may be lethal to white spruce, lodgepole pine and Douglas-fir; to avoid damage the spot should be kept at least 1 m away from crop trees.

SUMMARY

Chemical treatments integrated into a well-planned and well-conducted silviculture regime can increase growth and survival of both planted and natural tree seedlings. However, chemical weed control is not a panacea for poor silviculture prescriptions, poor stock quality or poor planting. The utility of this method can only be realized if every step in the regeneration process from pre-harvest planning through to free-growing survey has been conducted in a judicious manner.

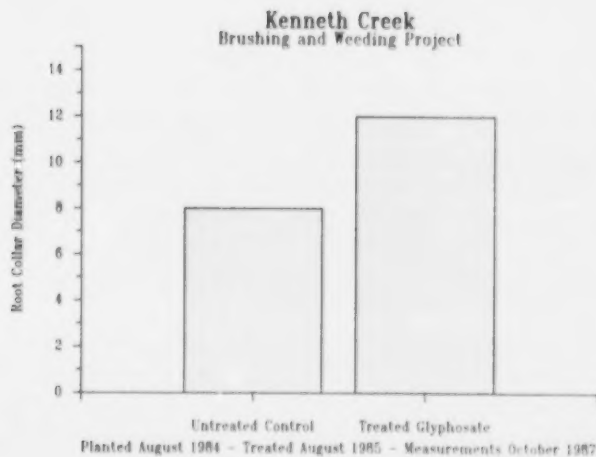


FIGURE 3. Stem diameter in untreated and glyphosate treated (2.14 kg/ha) white spruce seedlings. (data from post stand tending survey)

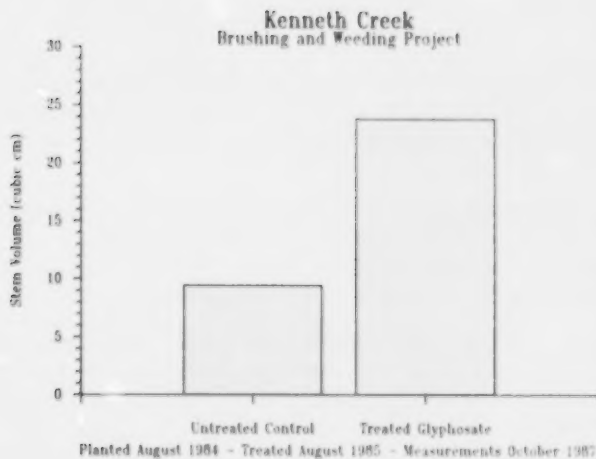


FIGURE 4. Stem volume in untreated and glyphosate treated (2.14 kg/ha) white spruce seedlings. (data from post stand tending survey)

Predicting Vegetation Management Problems

by
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Management of early seral vegetation is an important consideration when preparing sites for planting. Competing vegetation can be detrimental to seedlings' survival and growth. It can: intercept light and thus reduce the photosynthetic activity of the seedling; reduce the amount of solar energy getting to the soil around the seedling, resulting in reduced root activity; and remove soil moisture, resulting in moisture stress to the seedling. However, this same vegetation can provide benefits to the seedling in the form of shade from intense solar radiation, protection from winter exposure by enhancing snow cover protection, or increased nutrient availability from the turnover of nutrient-rich vegetative matter.

Since early seral vegetation plays such an important role in seedling survival and growth, it is important for forest managers to be able to predict the nature of the vegetation that will occupy a site once it has been logged and prepared.

There are five general types of silviculture treatments differentiated by how the treatment alters the composition and structure of the existing vegetation:

1. mechanical treatments in which larger vegetation is pushed aside or sheared off, but lower vegetation and humus are left relatively undisturbed (e.g. piling or winter shearing). In this case there is little change to the floristic composition of the vegetation, but its height and cover are reduced;
2. mechanical treatments in which small areas of mineral soil are exposed but much of the vegetation is left relatively undisturbed (e.g., spot scarification or mounding). The composition and structure of vegetation outside of the mineral soil patch is unchanged, and there will be no vegetation on the mineral soil until plants seed in or sprout up. Vegetation developing on the mineral soil is often of a different composition;
3. mechanical treatments through which large areas of mineral soil are exposed (e.g., plowing or deep blading). This treatment type drastically changes the composition and structure of the vegetation. The areas of mineral soil are soon occupied by pioneer species adept at colonizing mineral soil, usually by seeding-in;
4. broadcast burning in which most of all vegetation is removed but a portion of the humus remains. These sites are generally (depending on severity of burn) quickly occupied by species which are stimulated by the burning process, such as thimbleberry (*Rubus parviflorus*) or fireweed (*Epilobium angustifolium*); and
5. herbicide treatments through which one or more target species is removed or significantly reduced. The composition and structure of the vegetation is changed drastically. Vegetation that can take advantage of the space left open due to the reduction of the target species — generally species that seed in or are not affected by the herbicide — will occupy the site.

To be able to predict the vegetation that may compete with the seedlings on a site, we need to know the ecosystem unit that existed prior to disturbance and how vegetation of this unit will respond to the treatment types. Studying sites after treatment allows us to predict what vegetation may become a problem on another site prepared in the same manner.

We also need to know the nature of the vegetation making up the vegetation complex developing after treatment. To do this we must study various aspects of the autecology of the main competing species making up the vegetation complex. Some aspects to study for each species are:

1. leaf area — the more leaf area a species has the more light it will stop from getting through to the seedlings;
2. rooting location — if a species roots in the same profile as the young seedlings it will be more of a problem;
3. water use — the more a competing species uses, the less that is available for the seedling;
4. cover increase — the more rapidly the competing species can increase cover, the more shade it will cause and the greater distance it can be from the seedling and still shade it; and
5. maximum height — the maximum height the species will attain will determine if it will be a problem for a few years or will continue to be a problem for many years.

Finally, we must know how a given amount of a particular vegetation complex will affect seedling performance. In effect, we must attempt to find measures of the amount of a vegetation complex (i.e., competition indices) which are correlated with measures of the seedling's growth. One such competition index is:

$$CI = \Sigma [VH_j \cdot PC_j / Av_j]$$

where VH_j is the mean vegetation height for species j ; PC_j is the percentage of cover of species j ; and Av_j is the average distance from the centre of a seedling to the inner edge of foliage of species j . This competition index is essentially a measure of the volume of vegetation and its proximity to the centre of the seedling. The resultant index can be correlated with seedling growth, as measured by diameter increment, which is one of the better measures of a seedling's relative performance. In my studies of the relationship between the growth of hybrid white spruce (*Picea glauca* x *engelmannii*) and the above competition index, there was a negative relationship between increasing growth and increasing competition. The best correlation between the competition index and the diameter increment was at high levels of the index. This suggests that there may be a certain level of vegetation competition below which other factors begin to have as much effect on seedling performance as vegetation competition. This level may be one which forest managers may choose to use as the level of vegetation control they wish to achieve on a particular site.

As we proceed into an era of wider choice of site preparation strategies for controlling vegetation, it becomes increasingly important to be able to predict what effect each strategy will have on this vegetation. Through increased knowledge of changes in vegetation composition and structure after treatment, autecology of key competing vegetation species, and measures of vegetation competition which will correlate with seedling performance, we can begin to have this predictive capability.

Address to the Northern Silviculture Committee's Winter Workshop

by
Ben Marr, Deputy Minister
B.C. Ministry of Forests
Victoria, B. C.

The theme of your winter workshop — "Learning from the past, looking to the future" — is very appropriate and timely because of the new directions we have embarked upon in the field of silviculture in our province. In the past few months we have undertaken major initiatives in forest resource management. They represent the most extensive changes in our forest sector's history in the way we manage, charge for and renew our forests. They also reflect the government's goal of making our province more competitive, efficient and entrepreneurial in character, and one which offers economic opportunities and prosperity for residents in every corner of this vast land.

The major changes in the way we manage our forest resource were undertaken for three reasons:

First, we have a tremendous forest resource which must be managed effectively and efficiently for the long run.

Second, we have a strong and innovative forest industry, which can and must take on more responsibilities, and a young silviculture sector which is growing in importance, relevance and maturity.

Third, because our forest industry, in response to world market conditions, has worked hard in the past few years to increase efficiency, we have lost thousands of jobs, partly due to automation. Now we must take steps to restore employment in our primary industry.

In December 1987, the B.C. Legislature unanimously approved amendments to the *Forest Act* which change our forest management policies, particularly in the field of silviculture.

Before the *Forest Act* was amended, it had a section titled "Reforestation" to cover silviculture. As such, it was silent on "basic" silviculture. Now we have a very comprehensive and superior part in the act which addresses "basic" silviculture extensively. Basic silviculture is now mandatory under the *Forest Act*. So, too, is pre-harvest silviculture planning. We will be enforcing silvicultural performance and we will be auditing it.

Through this new arrangement, we intend to achieve our "steady state" goal: balancing harvesting and forest renewal.

The *Forest Act* now also ensures that the companies harvesting our timber will bear the costs and have the full responsibility for replacing our forests. Previously, the costs of basic silviculture were credited to the stumpage accounts. Now our forest companies with long-term tenures will assume the full costs for the basic silviculture that will be required to replace our forests after timber has been harvested.

We are confident that our forest industry will meet the goal of renewing every hectare that is harvested. It has the silviculturists, the professional foresters, the qualified technicians. And they have access to a growing silviculture contract community that will do most of the field work. This approach, we are sure, will significantly increase employment. It will also offset, to some extent, the loss of jobs due to the increase in automation in the forest industry.

Under our new policies, the private sector will grow most of the seedlings required for forest renewal. This means that forest companies will have the option of producing their own seedlings.

We want to make it quite clear that the B.C. Forest Service will ensure that the private sector will produce healthy, free-growing stands of trees. These stands will support the future industry and provide the forests for the public's enjoyment of wildlife and recreation.

Many groups have expressed concerns that the B.C. Forest Service will not be able to effectively enforce the new requirements under the *Forest Act*. Some have cited the recent media coverage of MacMillan Bloedel's controversial waste wood assessments. They say that it has publicly called into question the B.C.

Forest Service's capacity to audit industry foresters. They add that many people do not trust industry to realistically report the progress of their regeneration program.

You, and all the professionals in B.C.'s forest sector, are going to prove them wrong. We are going to do the best job we can to manage our forest resource. We are already taking the first step.

Earlier this week the B.C. Forest Service released a discussion paper on the regulations that will be required to effectively and efficiently implement the new provisions of the *Forest Act*. The discussion paper lists 12 subject areas and suggests the types of regulations that the B.C. Forest Service is considering to give teeth to the amendments. We encourage each one of you to read the paper and submit your comments to the director of our Silviculture Branch.

We are all collectively responsible for the management of our forest resource. We must, therefore, ensure that the regulations we will draft to implement the new provisions of the *Forest Act* are in keeping with the spirit and intent of the legislation and our new policies.

We also want to stress today that the 'reporting' provision in the amended *Forest Act* is clear. A professional forester's signature and seal are required on the silviculture performance reports submitted to the government. The B.C. Forest Service will audit some of these reports, and if we find problems, we will take action to correct the situation.

There are other measures to ensure compliance. They include:

1. scrutiny of Management and Working Plans for Tree Farm Licences by the public; and
2. public access to the Pre-Harvest Silviculture Prescriptions for Timber Supply Areas, and their results. These will be tabled with the TSA steering committees.

We will not expect companies harvesting timber under short-term licences to carry out basic silviculture. It is unreasonable to expect these licensees, especially under our Small Business Enterprise Program, to have silviculture expertise. Therefore, the B.C. Forest Service will share in the forest renewal responsibility.

These licensees, however, will still have to pay their way. The taxpayers will not subsidize them. We will require the full cost of basic silviculture to be paid before the timber is sold. The B.C. Forest Service will hold funds to ensure that the full renewal process in basic silviculture is completed. We will administer the work on these short-term licences, particularly those under the Small Business Enterprise Program. We will contract practically all the field work to the private silviculture industry. This will further create new jobs.

FOREST RESOURCE DEVELOPMENT AGREEMENT

In just two more years, the \$300 million Canada-British Columbia Forest Resource Development Agreement will come to an end. It is an important program, a crucial program, for the management of our forest resource.

Under this agreement, \$240 million are allocated for cost-shared programs. Approximately \$100 million of this amount is being spent on planting, brushing, weeding, conifer release and juvenile spacing. We need another federal-provincial agreement, this time a \$600 million program, to reduce the backlog of the not satisfactorily restocked forest lands.

FRDA II negotiations have yet to begin. We expect them to be lengthy. The provincial government supports FRDA II in principle. However, the federal government has not yet indicated its support. Perhaps Ottawa is not convinced that we need another development agreement. Perhaps the feds and the public need to hear from groups like yours about the benefits of FRDA and about the need for further work.

We would like to eliminate all backlog reforestation by the year 2000. Thanks to FRDA I, we are reducing the backlog, but we need to continue and increase the rate of reforestation under a second agreement if we want to reach our objective. You will be pleased to note that by the end of FRDA I we will have all the backlog in at least one forest region under control: that is, in the Vancouver Forest Region.

British Columbians can be proud of this success.

MINISTRY PROGRAMS

As of today, the B.C. Forest Service and commercial nurseries around the province have lifted the majority of the seedlings for this year's planting. We plan to plant 200 million seedlings this year, under the FRDA and the B.C. Forest Service's programs. Forest companies are expected to plant a minimal number of seedlings this year at their own cost under our new policies.

However, the mix will change in the 1989-90 fiscal year for two reasons: first, the privatization of the B.C. Forest Service's nine nurseries; and second, the private sector will be taking on more responsibilities for forest renewal. Thus, in 1989-90, approximately 175 million seedlings will be planted under FRDA and the ministry's programs. We expect industry to plant up to 55 million seedlings as their direct responsibility. This means a total of up to 230 million seedlings will be planted in 1989. In succeeding years, industry's portion will increase while the B.C. Forest Service's will decrease, as it should.

Along with this planting is site preparation, surveying and brushing — the full sweep of silvicultural activities.

CONCLUSION

We all recognize that B.C.'s silviculturists have made great progress in the relatively new field of silviculture in the last few years. Professionalism has been the byword in your area of expertise. We are therefore confident that you will make even greater progress under our new forest policies to ensure that we grow bigger, faster-growing and more valuable trees on our forest lands.

We, in the B.C. Forest Service, have made many policy changes in the past few months. Changes that are necessary. In today's rapidly changing and complex global economy, we must continually make adjustments. We must keep ahead of our competitors if we are to build a strong economy that will be capable of meeting the challenges and demands of the future. We are relying on your expertise and research to ensure that our province continues to advance and lead the way in the field of silviculture.

Success and Failure of Prescribed Fire in the North Central Interior

by
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This paper deals with reasons why broadcast burning, a relatively new technique in the Interior, has in a short period matured to be a sophisticated and efficient site preparation tool. Advances in hardware, techniques and guidelines for defining both purpose and timing of broadcast burns did not materialize until the lack of these tools was recognized as an obstacle to intelligent fire use in Interior forests. Interior broadcast burning posed an entirely new and different dimension of problems than had been encountered on the Coast.

Broadcast fire was virtually unknown in the Interior until the early 1960s, except for isolated instances in the Enderby and Lumby areas. In 1967 Section 116 of the *Forest Act* was extended to the Interior, which empowered the Forest Service to instruct licensees to broadcast burn logging residue for the purpose of hazard abatement. Many strictly silvicultural burns rode on the broad back of hazard abatement in this period. At this time the Forest Service adopted a strong leadership role, encouraging a reluctant industry. Because the Forest Service was responsible for treating some tenures, expertise was developed rapidly. Figure 1 shows the growth of broadcast fire use in the Sub-Boreal Spruce zone of the Cariboo, Prince George and Prince Rupert regions. Of greater relevance to this discussion is the curve at the bottom of the figure showing annual broadcast burn areas for the Prince George Region alone, including all zones.

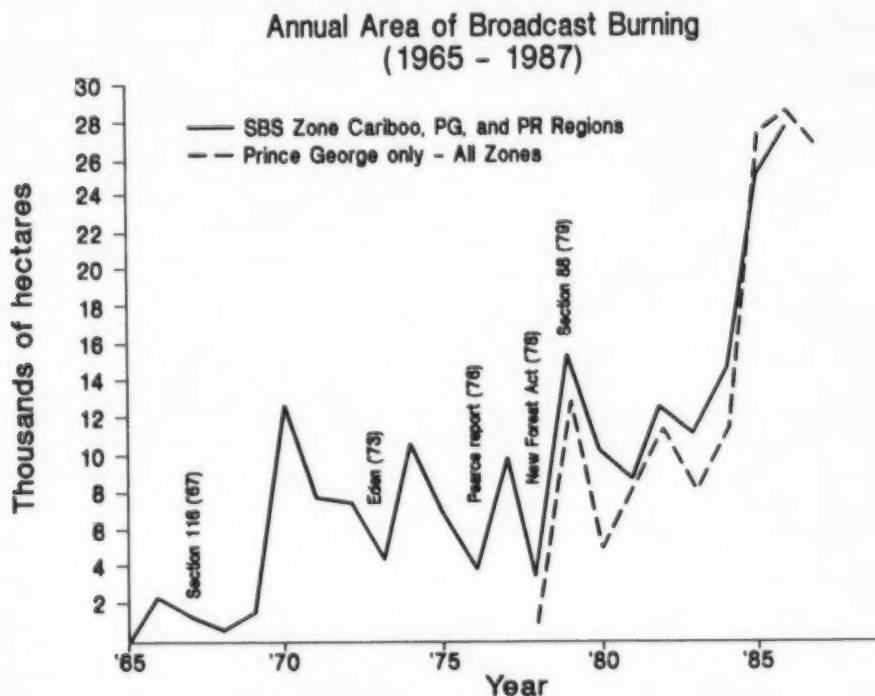


FIGURE 1. Annual area of broadcast burning - 1965-1987.

The success story of broadcast burning in the Interior is the changed attitude of land managers regarding its use and its resultant widespread application. Fortuitously, the ingredients required to make this happen came together throughout a twenty-year period:

1. development of efficient ignition techniques and the hardware required to put fire when and where required;
2. guidelines for developing prescriptions and relating fire impact to weather variables;
3. an aggressive "get the job done" attitude among line people; and
4. financial inducements provided by government policy.

DEVELOPMENT OF IGNITION TECHNIQUES AND HARDWARE

Interior fire use required a greater variety of ignition techniques, organization and hardware to cope with Interior blocks. Large openings with little relief and different types and arrangements of slash fuels required more ignition personnel lighting in more hazardous burning conditions and in more vulnerable areas to achieve desired impacts. In addition, central or walking convection columns were required to maintain control, together with machine guards to contain creeping groundfire. Interior stand characteristics providing abundant ladder fuels with intense drying on exposed forest floors precluded the use of fuel moisture differentials between slash and stand to maintain control.

To obtain ignition within the block, large numbers of personnel walked through the block with hand drip torches. The spectre of wind change, disorientation or a crippling fall required radio communication and a strong buddy system to avoid disaster.

Various efforts at achieving ignition in block interiors culminated in the prototype helitorch, developed by Northwood and the Canadian Forestry Service in 1973 and since refined in safety, versatility and efficiency. The AIDS dispenser, modified from an Australian system to be used primarily for underburning and habitat burns, rounded out the arsenal of aerial ignition hardware.

GUIDELINES AND BURNING PRESCRIPTIONS

Handbooks on prescribing broadcast burning and guidelines offering advice on how, what and when to burn were developed. Simultaneously, the Canadian Fire Danger Rating System was developed using a modular approach that would provide flexibility and the ability to use individual components of the system together or separately for a variety of purposes. The prescribed fire predictor applied the moisture codes to predict prescribed fire characteristics. The establishment of Environment Canada fire weather forecasters in regional offices provided forecasts for prescribed burning as well as other protection needs. Recently, economical telemetering stations have been developed by FTS Victoria.

ATTITUDE OF LINE PEOPLE

The prescribed fire achievements of the last decade would not have occurred were it not for the attitude of the people involved. The line people of both the Ministry and corporations were quick to respond to the challenges of prescribed fire, often without the wholehearted support of their superiors. Those that were staunch of heart and lucky prevailed, and today those people are in higher places with a healthier respect for fire and a great deal more support for their juniors.

FINANCIAL INDUCEMENTS

The last and in some ways most important ingredient contributing to today's success of fire as a site preparation tool was the financial coercion provided by Section 88 of the *Forest Act*, introduced for at least some activities in 1979. The convincing power of this funding was that it adequately covered both expected and unexpected costs but was coupled with stiff assessments for not treating. This carrot-and-club approach

was most convincing to corporate boardrooms and relieved line personnel of pressure. Prior to Section 88, the costs of prescribed fire were costed via the appraisal. Licensees who burned were forever complaining that actual costs exceeded allowances, probably true in adverse situations. Those licensees who did not burn paid relatively light assessments but in general gained by the stumpage allowance and would make only token efforts at treatment.

Although Section 88 would pay the costs, the job still had to be done before credits were granted, unlike the appraisal allowance which initiated reimbursement for site treatment with the first log removed. Both methods, however, shared the common fault of encouraging token treatments. Only after the positive effects of good burns on tree growth were realized did more progressive agencies emphasize achievement rather than attempt.

This article was to present the two aspects of success and failure of fire use. As far as I am concerned there were no failures. However, there were unfulfilled opportunities. Some of those opportunities that we failed to exploit in the past have become the challenges of the future.

The abolition of Section 88 funding and the return to the appraisal allowance for basic silviculture, including site preparation, places the responsibility on the Land Manager to get the best value for the dollar spent. This means burning to obtain the proper impact, planting the best stock and an overall increase in efficiency of silvicultural operations. At the same time, the very near future is presenting the spectre of smoke management, instigated by public concern. When this happens, we will have to be more aggressive in distributing burning load more equally through the summer to take advantage of faster, better-ventilated burns. We will not be allowed to overload the airshed in periods of marginal burning and poor ventilation indices that generally accompany fall drying regimes. Mop-up procedures for all burns will have to be more complete and quicker to reduce residual smoke. The not-too-distant future will also entail a greater number of smaller blocks in more difficult terrain. We will have to use new tools such as foam and expanded water systems, together with all of the burning opportunities available. A return to smaller blocks with their associated cost constraints will re-establish the usefulness of hand and pre-laid ignition systems and will reinstate after-dark ignition.

An open-minded, flexible approach will be the best guarantee of maintaining broadcast fire as a cost-effective silvicultural tool. An informed, vigilant attitude will maintain a favourable public attitude that will allow future use.

Summer Burning in the ESSF

by
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Much of West Fraser Mills (Quesnel) operating area lies within the ESSFh subzone. These areas are known as the Quesnel Highlands and the Cariboo Mountains. The terrain is typically rolling and varies from 20-24% grade. Therefore, it is very restrictive to mechanical site preparation usage. The ESSFh receives the greatest amount of precipitation of all the continental subzones in the Cariboo Forest Region. Annual precipitation ranges from 900 mm to 1320 mm, evenly distributed throughout the year. An estimated 50-65% of the precipitation occurs as snow, with higher percentages occurring at higher elevations (Webb 1976). Deep snowpacks of long duration develop each year. Dissipation of the snowpacks begins in May at the lower elevations and proceeds upslope through the month of June until timberline areas become free of snow in early July.

SOILS

The zonal soils of the ESSFh are Orthic Humo-Ferric Podzols. These soils are acidic in nature and are derived from moderately well drained, gravelly sandy loam, parent materials. These soils characterize a cool to cold, moist to wet climate, where soil chemical weathering is concentrated (Canadian Soil Survey Committee 1978). The forest floor is 4-10 cm thick and forms a continuous mantle over the mineral soil. The humus forms associated with these zonal soils are classified as Hemimors, which reflect a slow rate of organic matter decomposition typical of cool, moist climates (Klinka *et al.* 1981).

VEGETATION

Forests of the ESSFh are dominantly composed of over-mature Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) stands. Zonal ecosystems are composed of subalpine fir and Engelmann spruce in the tree layer. The dominant regeneration is subalpine fir with lesser amounts of Engelmann spruce. The shrub layer is generally moderately well developed. The herb layer is well developed with a large variety of herbaceous plants. The moderately well developed moss layer contains *Pleurozium schreberi*, *Ptilium crista-castrensis*, *Mnium nudum* and *Barbilophozia lycopodioides*.

BURNING

West Fraser Mills' burning program normally gets underway during the first part of June. For early ignition we look to sites having the following features:

1. south and west exposures located midslope. The snow leaves these sites early, thus allowing slash to cure satisfactorily for an early broadcast burn, yet still allowing the higher elevation areas to hold their snowpacks. These melting snowpacks provide a good moisture flow through lower elevation sites, helping to reduce the hazard of escape and also supplying much-needed water for mop-up. Most of the sites on these exposures have shallow duff layers. Deep burning of the soils is controlled by the cool, moist conditions existing during this time period;
2. sites that have adjacent plantations. The desired time to broadcast burn these sites is when the vegetation on surrounding plantations has developed full leafage. This will reduce spreading from spot fires; and
3. sites that have north and east exposures. These are the most difficult of all the sites to broadcast burn objectively. It is in these sites that summer burning really comes into focus, as it is most difficult to achieve desired objectives with a fall burn. In most cases, burning with desired codes (Muraro 1975)

can be accomplished during early summer if a representative weather station is installed and properly monitored.

To take full advantage of all available burning windows, each proposed broadcast burn should have:

1. 3-metre knock down completed (March-April);
2. fireguards where necessary;
3. sump holes constructed where possible;
4. fuel moisture sticks properly located (April-May);
5. representative weather station set up and operational (May);
6. suitable access for ignition and mop-up;
7. all necessary paperwork completed and in order (approved burning plan, etc.); and
8. mop-up equipment checked and operational.

In 1987 West Fraser Mills planned early summer burns for three sites. The first was an eastern exposure (69 ha) adjacent to plantations on two sides and a swamp and standing timber on the other two sides. Ignition took place on 8 June. Codes were: FPMC-89, DMC-24, DC-134. Ignition was by helicopter. The burn was well controlled, with some spotting in old windrows above the upper boundary. Mop-up was three days with a 12-person crew. The site received good coverage by the fire. Total cost per hectare for this block was \$336.67.

The second site was 233 ha located on a large flat with adjacent swamps on two sides and a creek and standing timber on the other two sides. Ignition took place on 16 June. Codes were: FPMC-88, DMC-17, DC-140. Ignition was with two helicopters. The block burnt well with minor spotting outside the guard on the south end. Mop-up was three days with a 26-person crew. The site received good coverage by the fire. Total cost per hectare was \$208.56.

The third site was 65.8 ha with a northeast exposure and slopes up to 40%. The west boundary was adjacent to a plantation. The other three boundaries were standing timber. Ignition was on 28 July. Codes were: FPMC-89, DMC-26, DC-242. Ignition was by helicopter. The burn went well with some fringe damage on the south side. Mop-up was three days with a 15-person crew. The block received fair coverage by the fire. However, duff reduction did not meet the objective set for this site; one of the main reasons was extensive brushing in. Total cost per hectare for this block was \$508.08.

We try not to schedule broadcast burns during July and the first half of August. Our records show that higher burning costs are incurred during this time period. One major reason for higher costs is the intensive mop-up required, mainly the result of the low night recovery factor.

With the advent of the spring and summer burning program, we have been able to achieve better all-around results with our broadcast burning. Being able to burn with desired indices rather than the "take it or leave it" indices of fall burning allows us to be more block specific in our objectives.

The 1987 burning season was a good example of how valuable spring and summer burning can be. During the last week of August we burnt 12 cutblocks (1218 ha). We had no serious problems with any of them during ignition or initial mop-up. On 1 September, the Ministry of Forests put a ban on all broadcast burning due to extremely dry conditions (summer build-up). This ban was in effect until 1 November; consequently, there was virtually no fall burning.

In conclusion, spring and early summer burning can be a useful tool in post-treatment programs. To achieve the desired results and do it economically, one must do a good deal of planning and preparation.

Kiwa Treatment Blocks

by
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These two blocks are approximately 250 km southeast of Prince George, east of the Rocky Mountain Trench. Both blocks face north, are ecotyped as ESSFo and have been identified as brush fields in the early 1980s. There have been four different treatments on the blocks. Block 83E002 #8 ("Block 8") has been divided into three treatments:

1. mechanical planting trails 1983, aerial herbicide 1985, planting 1984;
2. dip and dive 1984, planting 1985, aerial herbicide 1985; and
3. aerial herbicide and naturals.

Block 83E002 #6 ("Block 6") has the fourth treatment:

4. aerial herbicide, broadcast burn and plant.

BLOCK 8 — TREATMENT #1

In 1983, mechanical site preparation using an FMC with a six-way blade was attempted with moderate success on 12 ha at a cost of \$460.00/ha. The project was terminated when the machine caught fire and was destroyed.

In the spring of 1984, 12 ha of planting trails were planted at a cost of \$373.00/ha. The area is an active range unit and grass seed was applied by the range permittee. The 2+0 bareroot stock from S.L. 1530 was in trouble the next year — chlorotic, stressed and dying. Seed lot 1530 is genetically very questionable.

On 18 August 1985, 53 hectares in this block were sprayed with glyphosate at an application rate of 5 L glyphosate with 95 L of water per hectare. Average cost for the herbicide application was \$235.00/ha.

In May 1986 a regeneration survey made an assessment of NSR. More significantly, only 58% of the found planted trees were of acceptable quality. This was due, in part, to the seed lot and the amount of grass in the area. The area was prescribed for replanting in 1987 and an additional herbicide treatment in 1988. Part of the problem with the grass may have been the timing of the herbicide application, in that the grass had already dropped its seed and responded vigorously to the increased light and heat. The larger bush species — alder, willow and false azalea — had been effectively controlled by the herbicide. The vegetative competition for the planted trees in 1986 was raspberry and fireweed, along with the grass.

In the spring of 1987, these 12 ha were replanted with 860 spruce two-year-old 313 plugs per ha, at an approximate cost of \$430.00/ha.

Summary

To date, approximately \$1500/ha has been spent over four years. The assessment is that another herbicide treatment is needed and that the chemical tool may not be available to take care of the grass problem. The trees are planted in areas prone to trampling, and they are not large enough to survive the intensity of grazing that occurs in this block.

Recommendations

A brown and burn may have been a more efficient method of brush control but would not have solved the deep duff problem. Mechanical site preparation, followed by chemical treatment before planting, would have been more desirable. However, the original prescription may have succeeded if a better quality seed lot had been planted and only short grasses seeded after planting. Cattle should be restricted from grazing for at least three years after planting. This is even more critical when planting trails, which make excellent cattle trails, are employed.

BLOCK 8 — TREATMENT #2

In the fall of 1984, the FMC was employed to site prepare 36 ha. Dip and dive was completed at a cost of \$563.00/ha. In the spring of 1985, 35 ha of this area were planted with 42,000 spruce one-year-old PSB 313's, from seed lots 4200 and 3973, at a cost of \$249.00/ha. On 18 August 1985, 14 ha of this area were sprayed with glyphosate, at the same concentration and cost as in treatment #1. The total block was not sprayed because of concern for newly planted seedlings.

In 1986, a survey of the sprayed area indicated 82% survival. One of the causes of mortality noted was frost heaving of the 313 plugs. A regeneration survey over the whole plantation, done later in the summer, indicated that the 973 acceptable stems on the site had an average leader growth of 6 cm. A full 50% of the stems were restricted by brush.

The lower portion of the 1985 plantation which was sprayed, and is grazed, was replanted. Planting density in the area averaged 235 stems per hectare at \$118.00/ha.

Summary

The area is presently stocked with over 1000 stems per hectare of spruce and balsam, planted and natural, at a total cost of \$930.00/ha. There is minor erosion on the vertical trails, but there are no water channels over 9 cm deep and the trails seem to be stabilizing. This area is scheduled for a herbicide brushing in 1988 to release seedlings from the heavy brush encroachment.

Recommendations

This was a moderately effective treatment. However, herbicide treatment along with the dip and dive before planting would likely have provided significantly better growth and survival, eliminating the need for fill planting and possibly post-planting brushing.

BLOCK 8 — TREATMENT #3

History, Summary and Recommendations

Since logging in 1975, the only treatment this portion received was aerial application of glyphosate at 5 L/ha. The 1986 regeneration survey indicated that the area was stocked with more than 1000 stems of good-quality spruce and balsam. The herbicide seems to have been successful in releasing the already established naturals. We were lucky to get good natural regeneration, since experience has shown that most sites in the ESSF do not regenerate naturally.

BLOCK 6 — TREATMENT #4

On 18 August 1985, aerial application of glyphosate was completed at a cost of \$235.00/ha. As a result of high brush, steep hillside and remaining residuals, the height above ground level for the helicopter was between 20-25 m. All these factors, along with a herbicide dosage of 5 L/ha, combined to leave some gaps in the coverage and only minimal control of the slide alder, which was abundant on the skid trails. The visual impact of the slide alder was quite severe, but closer inspection indicated that there was 60-70% reduction of leaf surface on the sprayed alder.

At approximately 3:00 p.m. on 8 August 1986 aerial ignition was started. Temperature was about 17°C, with light winds, partial overcast and 42% R.H. (For drought codes and burning condition ranks, see Burning Summary.)

Expected precipitation did not materialize. Drought codes rose steadily until 20 August, when the DMC was 50 and the DC was 479. Mop-up and control action was taken. This brought total burning cost to \$205.00/ha.

The 70 ha block was divided into two planting units. Unit A was the majority of the broadcast burned section, with the exception of 5 ha in the southwest corner. This unit had a planting difficulty rating of 23, with

1165 plantable spots per hectare. Unit B was the 10 ha buffer strip along the north boundary which was not herbicide treated, and 5 ha in the southwest. It also had a planting difficulty rating of 23 and 640 plantable spots per hectare. Unit B was considerably more flat and less rocky than Unit A, but brush and residuals were a factor.

Unit B was shovel planted with spruce 2+1 bareroot from seed lot 4177. Unit A was shovel planted with spruce 1+0 PSB 313's from seed lot 4200. In Unit A, because of small stock and expected high brush, 1600 stems per hectare were planted instead of the standard 1200 larger seedlings. This, combined with contractor difficulties, forced the price to \$775.00/ha, 30% over anticipated costs.

Summary

The actual brown and burn has had the most dramatic change in vegetation growth pattern. The planted trees are too young to make assessments for survival and growth. This block, one year after burning, has vegetation which will likely provide strong light competition for planted stock. Treatments on this block to date total \$1216.00/ha.

Recommendations

Wait one year before attempting to burn and do the burning during the highest indexes. Very good pre-lightup prescription and fireguarding are required.

FINAL SUMMARY

On slopes of less than 30%, to gain desirable site preparation for planting, brown and burn for brush control and mechanically site prepare for duff disturbance and warming. On slopes over 30%, the dip and dive method is not highly desirable, as the trails are good seedbeds for all the brush left between the spots, and full, well-spaced stocking is not a reality.

To start a project on this area, in the same conditions as in 1981, the prescription, except for the area of natural regeneration, would be to brown and burn, and plant with large, vigorous stock.

Burning Summary

Area 83E002 #6 - Kiwa Brown and Burn

Biogeoclimatic	Association	Aspect	Slope
ESSFo	01	North	40%

Burning conditions

Date	FFMC	DMC	DC	Ignition Rank	Spread Rank	Control Rank	Impact Rank
86.08.08	89	21	406	6	5	6	5

Area Prescribed: 70 ha. Treated: 70 ha.

Plant spots prepared: 1200 per ha.

Costs:	Light-up	\$ 1970.00
	Mop-up	11055.00
	Overhead	1332.51
		<u>\$14357.51</u>

Site Rehabilitation Burning Considerations in North Central British Columbia

by
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This summary presents some considerations regarding the use of prescribed fire in site rehabilitation drawn from observations of burns carried out in FRDA Research Projects 1.5 and 1.20 in north central British Columbia.

Prescribed fire is an effective site preparation treatment for current-logged areas in the northern interior. It can be used to treat large areas at relatively low costs and may be used where slope conditions or proximity to water courses make mechanical or chemical treatments undesirable.

The potential amount and continuity of burnable fuels on backlog NSR areas largely determine whether fire can be used to treat these areas and if fuel creation and preparation are required. A fairly continuous layer of dry fine fuels near ground level and/or a dry litter layer is necessary for fire spread. Live vegetation tends to reduce fire spread by shading the forest floor, retarding drying, and by acting as a heat sink during burning. Fuel preparation is usually required to increase the supply of dead, dry fuels where vegetation is well developed. Mechanical treatments such as hand slashing or knockdown with bulldozers are used on sites with residual trees or large shrubs to improve fuel structure by compacting vegetation into a fuel bed, and to allow drying of the cut vegetation and forest floor. Adequate time must be allowed for fuel curing before burning. Herbicides may be used to dry and kill vegetation and allow more rapid drying of the forest floor, but they do not improve fuel structure. The timing of herbicide application and the timing of burning depend on the mode of action of the herbicide used, the susceptibility of the vegetation and its rate of regrowth. Effective spray and burn treatments may reduce the need for subsequent brushing and weeding treatments. Spraying must be carried out early in the growing season to allow for adequate vegetation kill and drying if burning is planned for the same year. Burning the year following spraying may be possible if a translocated herbicide is used and resprouting is minimal.

PRESCRIPTION ELEMENTS

The key elements in developing prescriptions for burning are:

1. defining site preparation and management objectives such as increasing planter access, vegetation control or maintaining site productivity in physical terms such as the degree of fuel reduction or forest floor depth-of-burn required; and
2. defining burning conditions such as fuel preparation, fuel moisture, weather and ignition pattern and method that are required to achieve the desired impact, with satisfactory ignition and spread and acceptable risk of escape.

The current guide to prescribed burning (Muraro 1975) gives fuel moisture conditions in terms of Canadian Forest Weather Index (FWI) System moisture codes (Canadian Forestry Service 1984) required to achieve desired ignition spread, impact and control ranks. However, currently there are few data to suggest the degree of fire impact required to achieve desired management objectives in most B.C. ecosystems.

BACKLOG NSR FUEL TYPES

Specific guidelines are required for site rehabilitation burning because backlog NSR fuel types are physically distinct from current-logged slash; different fire behaviour and impact would be expected in such fuels under the same burning conditions. Viñanek and Feller (1985) identified several broad fuel types where fire may be useful in site rehabilitation or stand conversion in northern interior B.C.:

1. "brushfields" (SBS, ESSF, ICH zones);

2. NSR areas dominated by unmerchantable subalpine fir (SBS, ESSF zones);
3. overstocked lodgepole pine stands (SBS, ESSF zones);
4. aspen stands (BWBS, SBS zones); and
5. decadent or overstocked cedar/hemlock (ICH zone).

Operational and experimental burns have been carried out in the first two fuel types in FRDA Projects 1.5 and 1.20, respectively. Some observations on burning conditions and fire behaviour, impacts achieved and fuel moisture trends follow.

BRUSHFIELDS

"Brushfields" are sites with well-developed shrub or herb-shrub complexes, where there are no fresh coniferous slash fuels. Such sites usually require herbicide treatment before successful burning. Vegetation development varies greatly between ecosystem types and with time since disturbance. In brushfields arising after clearcutting, vegetation biomass tends to increase over time since logging, while the amount of fine slash fuels tends to decrease (Figure 1).

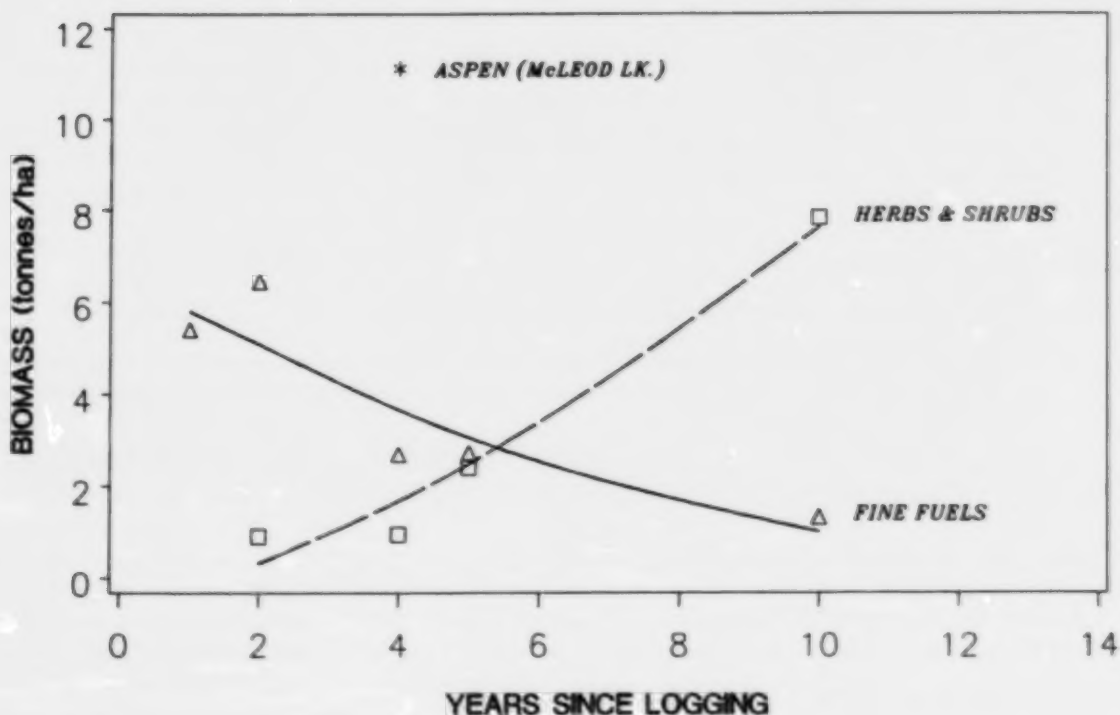


FIGURE 1. Trends in fine slash fuel (<1 cm diameter) and vegetation biomass following clearcutting.

Though 2,4-D has been used for brown and burning in the past, glyphosate is now more likely to be used. Species susceptibility to glyphosate varies seasonally, so spraying should be timed to coincide with maximum susceptibility of the dominant species, but early enough in the year to allow for kill and drying if burning is planned for the same year. A mid-June glyphosate spray provided good browning by early August (six weeks) in a twinberry-fireweed vegetation complex, but more time may be required for large diameter or less susceptible species. The structure of the brushfield influences herbicide delivery. Where aspen or other tall shrubs are well developed, slashing may be required to increase herbicide penetration and subsequent browning of underlying herb and shrub layers. No data are available to suggest fuel moisture and FWI System index values suitable for spray and burns in Interior brushfields.

The possibility of burning without browning was investigated on a brushfield four to five years after logging. Ignition was attempted on several occasions between 11-21 August 1986 at values of FPMC 86-90, DMC 23-31, DC 221-267 and ISI 3-6. The fire did not spread well beyond the accumulations of slash remaining from logging. Fire behaviour was also observed on a 3-year-old brushfield which was part of a large block that included fresh logging slash. The block was ignited on 26 August 1985 at values of FPMC 81, DMC 53, DC 337, ISI 3. Satisfactory spread was achieved in this situation, probably because of the drier conditions, and because the slash was more recent. However, the higher DMC and DC values also imply higher fire danger conditions. Burning without browning should be limited to situations with adequate woody fuels and where burning can be carried out safely under high fire danger conditions.

SUBALPINE FIR DOMINATED NSR

Fire may be used to treat selectively logged stands considered NSR although dominated by unmerchantable subalpine fir. Though understory vegetation is often well developed on these sites, knockdown of residual conifers provides fuel to aid in fire spread. The amount and distribution of fuel following knockdown depends on the structure of the residual stand, which in turn is dependent on the original logging method. Slash coverage following knockdown tends to increase with the residual stand density or basal area (Figure 2), while understory vegetation cover tends to decrease with density of the residual stand. Slash distribution may be modified during knockdown; if hand falling is carried out, trees can be dropped into openings. If salvage logging is carried out in conjunction with knockdown, the coverage of fine fuels may be increased due to limbing or skidding. Slash will cure much more rapidly if stems are completely severed; if bulldozers are used for cabling or walking down the stand, stems are often not severed, and curing will take much longer.

Two late spring burns and one late summer burn with an adjacent spray and burn treatment clearly showed the effects of fuel distribution and fuel moisture on fire spread and impact. The spring burns were carried out following knockdown the previous winter, and the slash was not well cured. Satisfactory spread and impact were only achieved in areas with high slash coverage. In the late summer burn, better spread was achieved in areas with low slash cover, probably because slash fuel moisture content was lower, though fuel moisture code values were similar to the spring burns. Fire spread was not complete in areas with high vegetation cover and little slash, though it was complete in all areas that had been sprayed with glyphosate before burning. Forest floor depth reduction was also slightly greater in the spray and burn treatment. Pre-burn herbicide spraying may also broaden the burning window, allowing for treatment under lower fire danger conditions.

The moisture content of slash was observed in the first season following knockdown. The pattern of drying of uncured medium and large subalpine fir slash was not strongly related to rainfall (Figure 3). Although the FWI System moisture codes were not specifically designed to represent the moisture content of slash fuels, FPMC was fairly well correlated with the moisture content of cured fine slash, but none of the moisture codes were well correlated with the moisture content of large slash fuels.

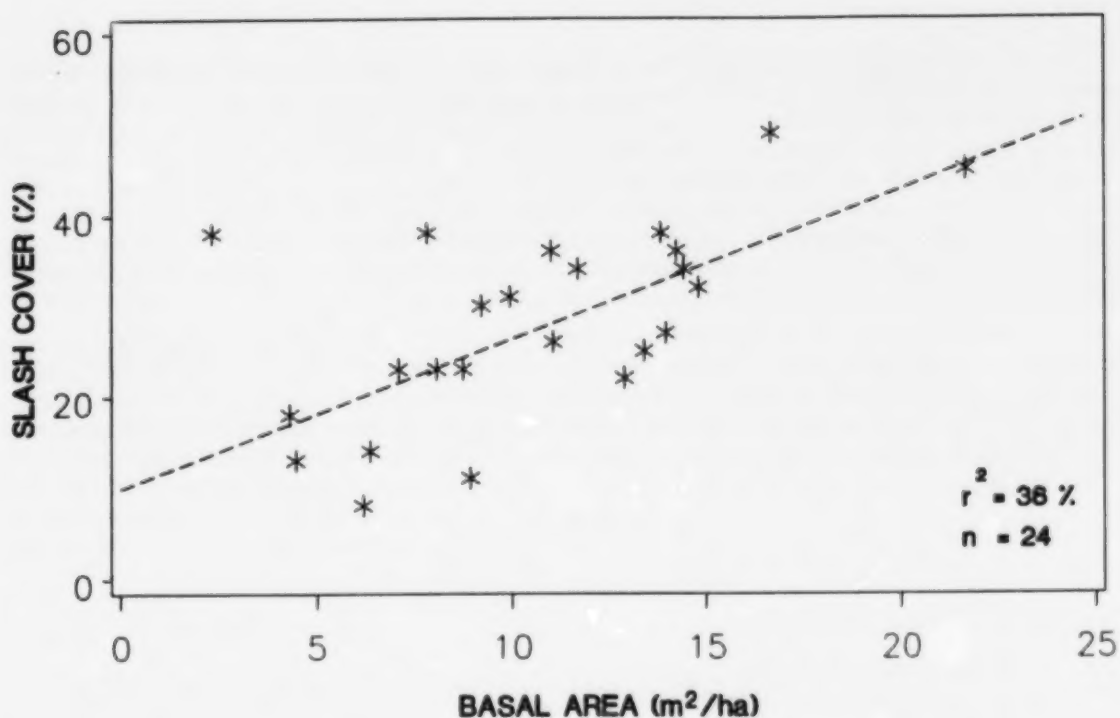


FIGURE 2. Relationship between slash cover following knockdown and basal area of a residual subalpine fir stand.

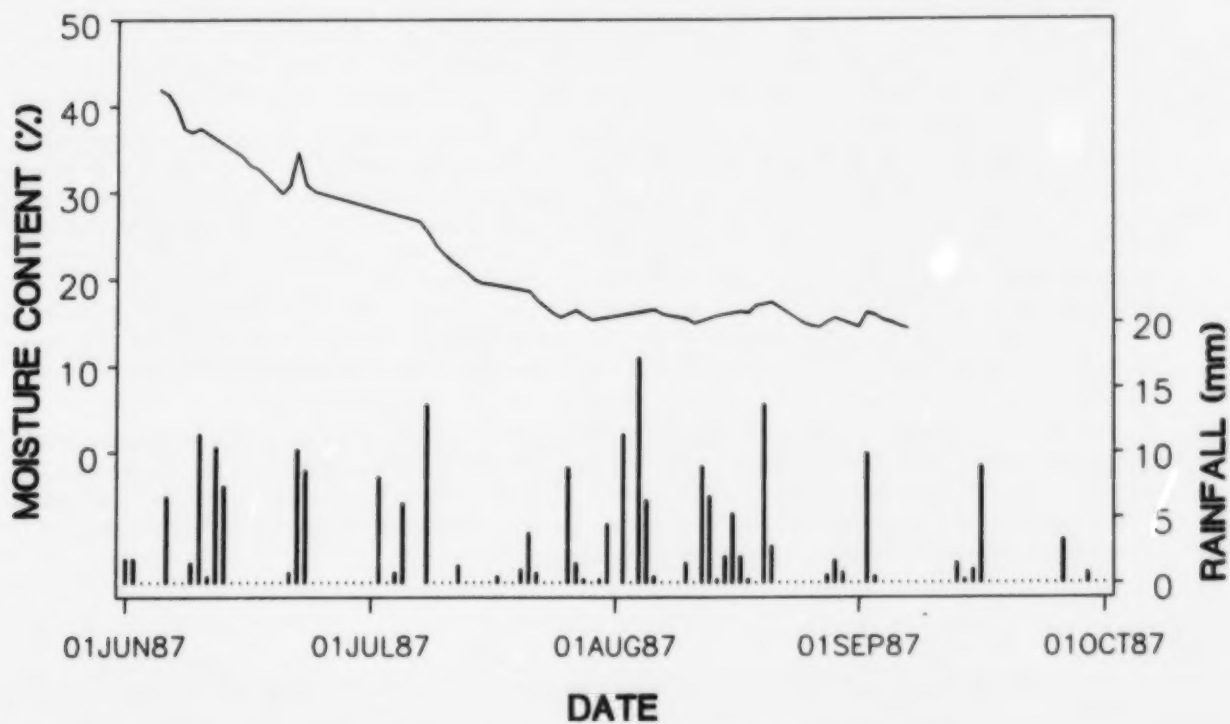


FIGURE 3. Drying trend of 2.0-5.0 cm diameter subalpine fir slash following winter knockdown.

FUTURE WORK

Additional data on burning conditions and fire behaviour and impact on backlog NSR sites will be gathered in Project 1.5 in order to refine prescriptions. Vegetation and plantation development following burn, spray and burn, and mechanical site preparation treatments on a backlog NSR site that had been selectively logged are being examined in Project 1.20 to determine the efficacy of these treatments. Development of woody fuel moisture codes accessory to the FWI System for use in planning prescribed burns is also continuing.

CONCLUSION

There are good opportunities for the use of prescribed fire in site rehabilitation in the northern interior. However, the use of fire in such programs requires more effort in scheduling and supervision than some other treatments. Good cooperation between silviculturists and prescribed fire practitioners is required in the planning and execution of treatments.

Revegetation after Prescribed Burning in the Sub-Boreal Spruce Zone

by
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Prescribed burning is used on over half of the area harvested in the Sub-Boreal Spruce (SBS) Zone to prepare sites for planting and to reduce fire hazard. The steep, rough terrain and unstable soils typical of many sites in the SBS restrict the use of other site preparation treatments. Burning is also more cost-effective than other treatments. In the Prince George Forest Region much of the future harvesting is scheduled for the wetter SBS subzones, and therefore the most cost-effective preparation treatments for these sites must be determined.

Ecosystem-specific information on the rates and patterns of vegetation development after burning and the impacts of vegetation on crop trees is needed to facilitate:

1. assessment of the suitability of burning on different sites;
2. determination of optimal burning prescription where burning is appropriate;
3. prediction of need for and scheduling of brush control after burning;
4. optimal scheduling of free-growing surveys; and
5. selection of appropriate stock for brush-prone sites.

Knowledge of the response of vegetation to burning is particularly crucial where there are environmental, social or economic restrictions on the use of brushing and weeding treatments. Selection of site preparation treatments that will minimize brush problems is essential.

In the wetter SBS subzones, where burning has often been used to prepare sites for planting, almost half of the plantations are considered Not Satisfactorily Restocked (NSR), due in part to the presence of shrubby and herbaceous vegetation which may contribute to snow press damage and may shade seedlings.

Burning severity is an important determinant of the response of individual species in some areas, and different vegetation complexes emerge after severe compared with light burns. However, we lack information on the negative impacts of different vegetation complexes, essential to determination of the optimal burning strategy in brush-prone ecosystems.

It must be determined whether higher impact burns can be used to alter the composition or control the level of vegetation and therefore improve seedling performance. If higher impact burns can be shown to result in vegetation complexes that have less impact on crop trees, then the benefits of burning under the high drought codes necessary to achieve a higher impact burn would warrant the extra costs (i.e., control and mop-up).

The response of individual species to different burning intensities can be predicted to some extent from the mode of re-establishment after burning, i.e., ability to resprout, presence of seed banks and ability to establish from off-site seeds. The depth of the perennating organ and ability to tolerate burning will determine resprouting ability. The degree to which germination of buried seeds is stimulated and a suitable seedbed for off-site seeds is created by different burning intensities will be important determinants of the revegetation process. The rate of vegetation development determines the duration of negative interactions with non-crop vegetation, thus it is essential to an overall assessment of plantation performance.

With all this information one can assess the suitability of different burning prescriptions. In some cases it may be preferable to maintain the initial vegetation intact on site.

RESPONSE OF VEGETATION TO BURNING IN THE SBS ZONE

Vegetation Regrowth Rates and Patterns

On submesic sites, shrubby and herbaceous vegetation grows to a height of about 75 cm by five years after burning (Figure 1). Where aspen is common before burning, suckering will occur and sprouts can grow to over a metre by one year after burning. On subhygric sites, vegetation can reach a height of about one to 1.5 m in five years.

Vegetation on submesic sites will reach 100% cover by about three to four years after burning, while on subhygric sites complete vegetation cover can develop within one to two years after burning (Figure 1).

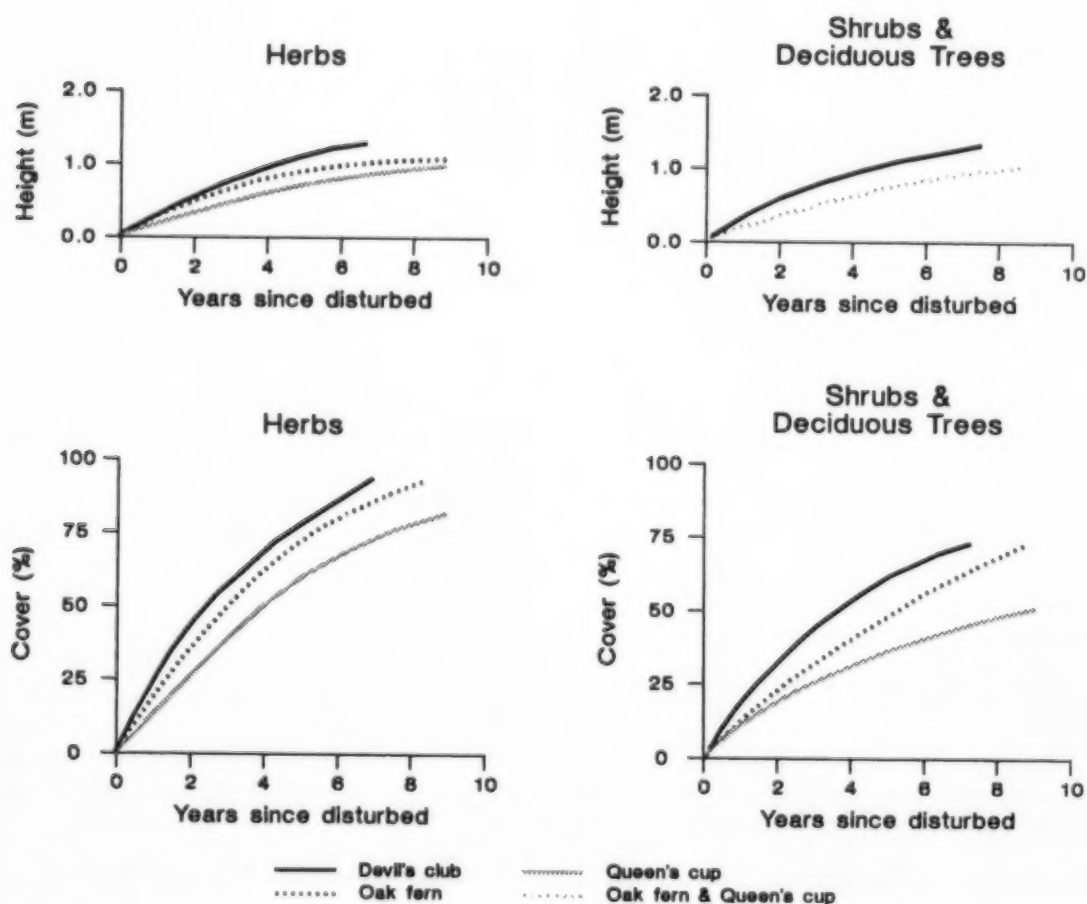


FIGURE 1. Increases in the height and cover of vegetation in three ecosystems in the SBS zone.

Vegetation growth rate is considerably slower on submesic sites compared with subhygric sites. Vegetation volume on submesic sites begins to reach a plateau by about five years after burning, whereas on subhygric sites vegetation volume continues to increase for the first six years (Figure 2).

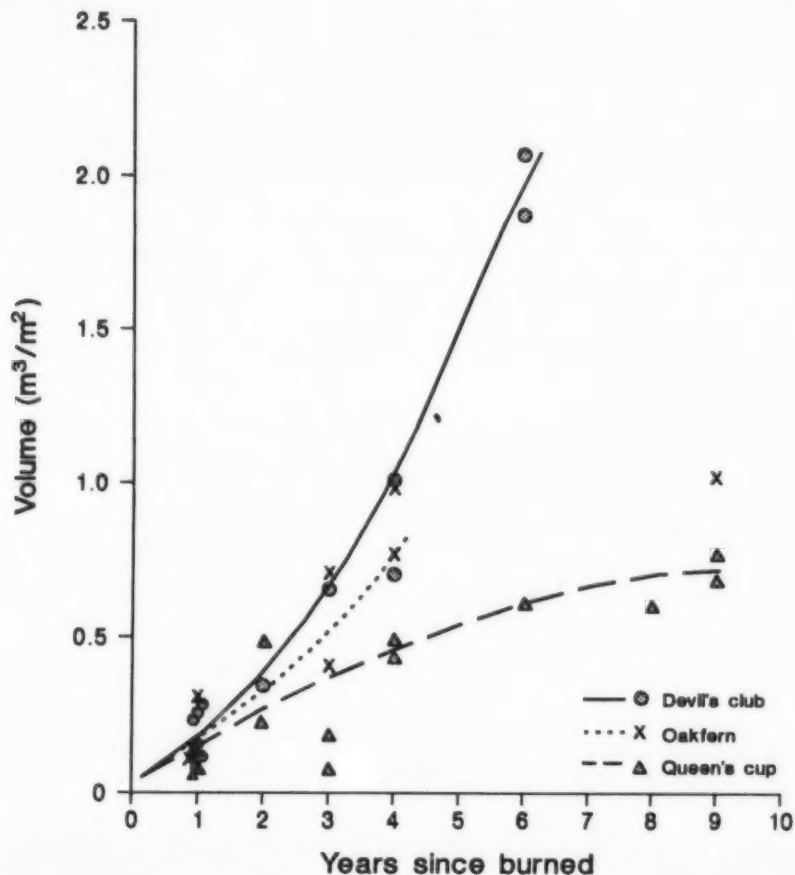


FIGURE 2. Vegetation development in three ecosystems in the SBS zone.

Lodgepole pine seedlings planted on submesic sites will readily outgrow most ground level vegetation, except aspen. On subhygric sites, shrubs and herbs will overtop spruce within a few years after burning and may continue to shade seedlings for five years or more.

Relationship between Burning Severity and Vegetation Development One Year after Burning

The average depth of burn was 5.3 cm on submesic sites and 3.0 cm on subhygric sites. There was more than twice as much vegetation on subhygric sites one year after burning (Figure 3). Vegetation cover was 28% on submesic sites and 60% on subhygric sites one year after burning.

Key species' response to burning may be seen in Figure 4.

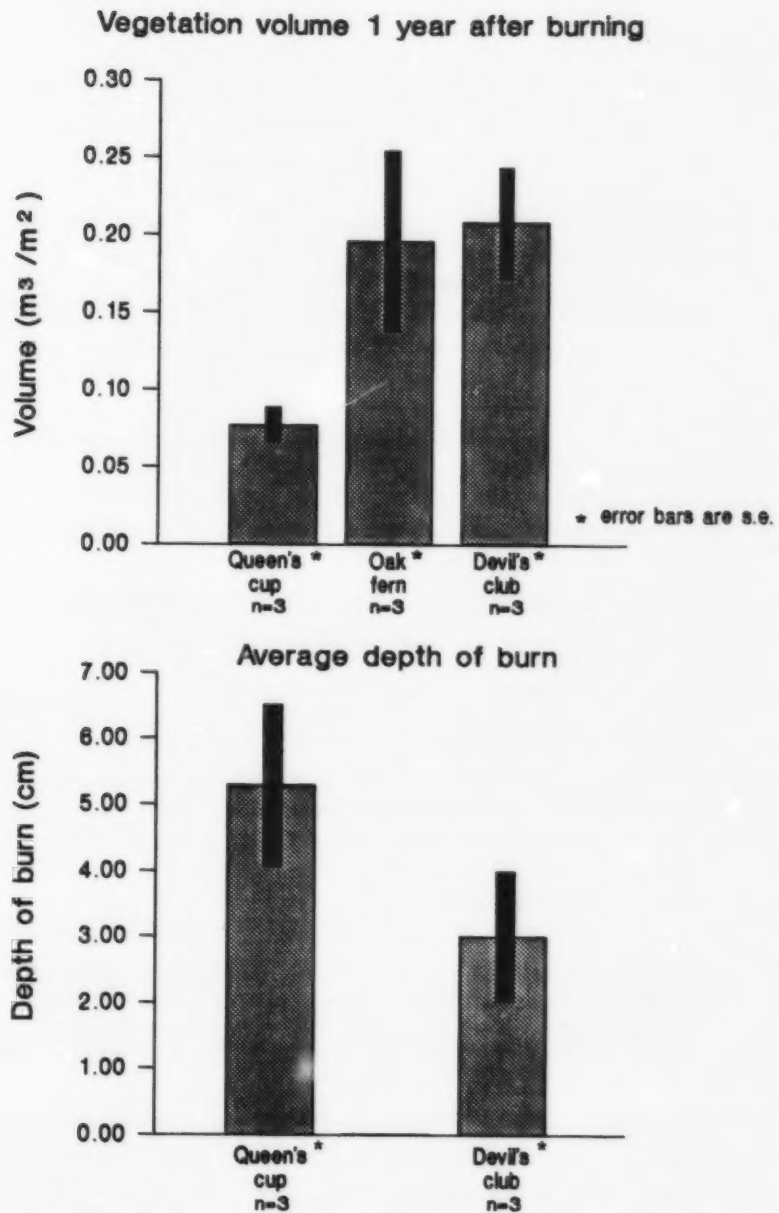


FIGURE 3. Average depth of burn and vegetation volume one year after burning in the SBS zone.

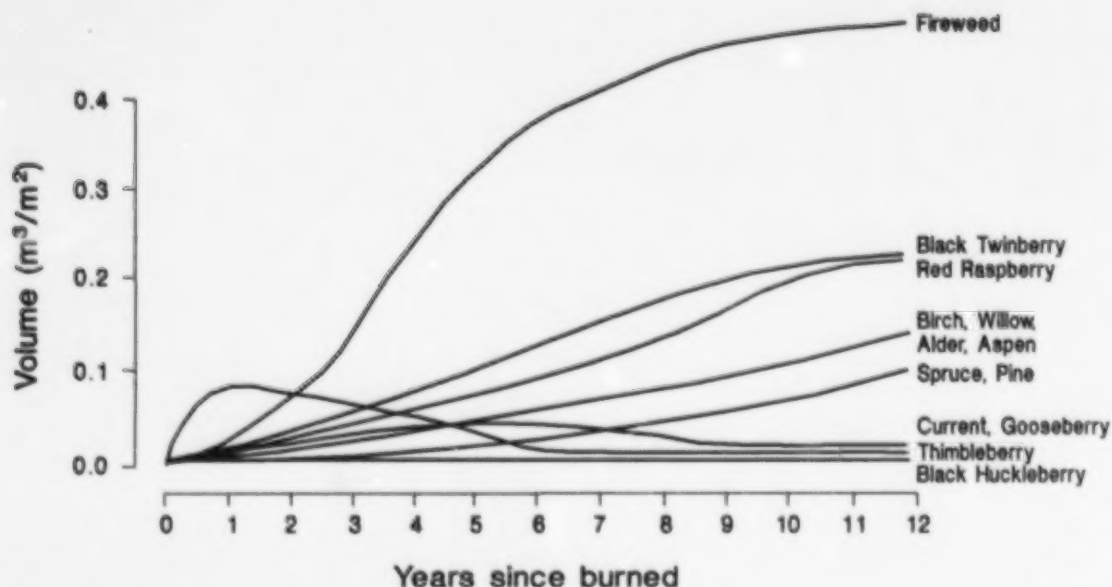


FIGURE 4. Schematic representation of vegetation development after burning in the SBS.

Vegetation development patterns in different ecosystems will be determined by burning severity, which will influence the degree of resprouting and establishment success of off-site seeds. Vegetation on the drier sites in the SBS may be killed by severe burns. However, only short-term reductions in vegetation cover occur on subhygric sites. Burning promotes the sprouting of fireweed from rhizomes and establishment from seeds. Fireweed will dominate most sites until overtopped by conifers or other taller vegetation. Burning also stimulates the germination of seed-banking species, including elderberry and red raspberry. Aspen, thimbleberry and lady fern resprout immediately after burning and are common in most sites. Other species, including black huckleberry and black twinberry, are less tolerant of burning and are slow to regrow. Birch seeds-in over time and resprouts from root crowns.

CONCLUSIONS

Some combinations of plant species may be more detrimental to crop trees than others, and burning strategies should be designed to limit the development of more problematic vegetation complexes.

By knowing the rate of regrowth one can predict the risk of snow press damage and the degree of shading and better determine the need for vegetation control.

If we know expected crop tree growth rates we can assess if and when vegetation will overtop trees. This will have implications for timing of free-growing assessments and the scheduling of brushing and weeding programs.

Wildlife Interactions with Silvicultural Treatments

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Much can be learned from the past about wildlife interactions with silvicultural practices. In this article we summarize ten broad areas of interaction between wildlife and silviculture that are potential problems. Looking to the future, we offer partial solutions. If past trends are repeated, most of these problems will increase before we address them. We have the opportunity, however, to learn from the past by applying innovative solutions while we still have the option.

POTENTIAL PROBLEMS

1. The best sites for forestry are sometimes the best sites for wildlife.

The places where trees grow well, and more intensive silviculture is merited, are usually the places best stocked with wildlife groceries. They also tend to support the greatest diversity of wildlife species.

2. There can be too much of a good thing.

Until recently the practice of clearcutting mature forests created more diversity in vegetation and often benefited major wildlife species. Initial benefits of clearcut harvesting are decreasing as larger stands, at ages unproductive for wildlife, accumulate. Similarly, silvicultural practices such as vegetation management or spacing were, until recently, sufficiently uncommon that they had little, or a beneficial, impact on wildlife. That is no longer the case. We are beginning to pass the threshold below which silvicultural practices have a beneficial effect on wildlife.

3. It is easy to be down on what you aren't up on.

Because forestry activities were often favourable to wildlife, neither foresters nor wildlife biologists were up on the potentially negative impacts. As silviculture becomes more intensive the negative impacts will become more clear. Unfortunately, they are becoming more clear under conditions in which neither group fully understands the consequences and each has too little practice communicating with the other to foster complete trust.

4. Weed species are often wildlife groceries.

Use of herbicides to eliminate potential competition with crop trees can eliminate wildlife forage. Key wildlife species such as moose rely on those weeds, especially willow and red osier dogwood. The sites the forester most wants weed free are often the sites that are the best at producing forage.

5. Spacing can be a problem or an opportunity.

Spacing can be a problem to wildlife if prescriptions acknowledge only silvicultural objectives. Spacing debris not only impedes wildlife access but also discourages the growth of understory forage. Foresters may also generate problems for themselves. Spacing debris provides ideal cover for small rodents and hares, capable of considerable damage. Implemented unwisely, silvicultural prescriptions can provide the rodents cover and deny them forage, thus encouraging their feeding on adjacent crop trees.

6. Deciduous conversion can be wildlife subversion.

Aspen and cottonwood provide high wildlife values. They provide excellent summer and winter range for moose, summer range for deer, and permit high diversity of other species. Among those other species are many predators on small mammal pests. This problem is connected with 'too

much of a good thing'. Effective fire protection and suppression have reduced the rate at which deciduous habitat is created. Conversion will increase the rate at which it is lost. The results for wildlife are grim.

7. Wildlife trees are serious business.

This problem is part of being 'down on what we aren't up on'. In the past, large deciduous trees have been left — aspen, cottonwood, birch. Increasingly 'tidy' forestry results in the removal of cavity-bearing wildlife trees and the increased application of herbicides reduces the potential number of deciduous wildlife trees. Such forestry practices can significantly reduce wildlife diversity and are not only unprofessional but also unhealthy. There is increasing evidence that, although insectivorous birds cannot control insect outbreaks, they significantly reduce insect pests.

8. Big wildlife need trees too.

Consider mule deer as an example. Deer require protection from deep snow and, in many areas, require an arboreal food source. These are supplied largely by mature and over-mature trees, especially Douglas-fir. Big investments in intensive silviculture will shorten rotations and add financial pressure to harvest at economic maturity, leaving little, if any, wildlife habitat for deer.

9. More damage is coming.

The apparent incidence of damage increases with more intensive silviculture for three reasons. First, as we attempt to shorten rotations we pay more attention to the loss of three to ten years' growth. Second, the more completely the crop tree occupies the site, the fewer alternatives wildlife have as food sources. Silviculture may work to focus feeding on the crop tree. Third, reduction of diversity usually reduces predators that were providing free pest control.

10. Ignoring diversity is deadly.

We are learning that diversity of wildlife can benefit forestry (problems 6, 7 and 9). Acknowledging only forestry in silvicultural prescriptions is like pushing a rope — it is hard to do, doesn't get the rope very far, and ignores common sense.

PARTIAL SOLUTIONS

1. Acknowledge reality.

Not all problems have solutions. There are, however, examples where imaginative silviculture has attained more than one objective. The first step is recognizing that there are two worthwhile objectives.

2. Recognize limits.

Accept that when we repeatedly apply the same practice to a finite area (e.g., watershed) we change the area's character. Practices that initially might have beneficial effects on both wildlife and forestry no longer do as particular limits are exceeded. Some practices — deciduous conversion, herbicide application — now merit discussion about their allocation over time and space.

3. Grow generalized ears.

History tells us that we do not develop successful, integrated silvicultural prescriptions until we understand the language of each resource manager. Foresters and wildlife biologists have different concepts of risks, different faiths in technology, different clients — broadly, different languages. A first step is understanding those languages, growing generalized ears.

4. Stop the arm-waving.

Both forester and wildlifer are guilty. The wildlifer assumes that abundant groceries are synonymous with good range and probably overestimates the amount of wildlife forage necessary. The forester assumes that poor regeneration success is due to competing vegetation. Both, likely, are only partially correct. There are ways to reduce conflict between the two resources: e.g., wider buffers where appropriate and mechanically treating weed species on selected, documented, good winter ranges. (They will resprout, providing forage as the crop trees grow).

5. Make spacing an opportunity.

Where the need for large wildlife forage is clear, space earlier (less debris, retains understory) and wider (more groceries). Both forestry and wildlife objectives have been attained in other areas; with generalized ears they can be here as well.

6. Broadleafed is broadminded.

Conversion of all deciduous stands would have negative impacts on both wildlife and forestry. Select areas for retention considering both resource objectives. Riparian areas are prime areas for deciduous retention.

7. Get serious about wildlife trees.

We have two alternatives: 1) finally be legislated by restrictive rules to maintain wildlife trees, or 2) use generalized ears to develop an integrated approach. We can begin by considering how to maintain snags and some large deciduous trees. Riparian areas are again ideal candidates.

8. Bigger is not always better.

The juxtaposition of cover and forage is important to wildlife. Managers should consider smaller cutblocks, and the type and importance of adjacent cover. Smaller blocks and more edge would increase the diversity of wildlife.

9. Look ahead.

Because more intensive silviculture usually increases the incidence of damage, quick fixes are unlikely. Some aspects are obvious; if you can delay, it is daft to plant during a hare or small rodent peak. Other approaches require imagination and generalized ears. Even so, foresters may have to accept some losses. However, they may not be formidable if we also retain habitat diversity.

10. Don't push the rope.

There are costs to managing for diversity, but there are also benefits. Sooner or later we must manage for diversity. It is better to begin now and do it relatively cautiously than to wait for a game of 'catch up' and the greater likelihood of costly mistakes.

It all comes back to the theme of this workshop — we must learn from the past to shape a better resource future.

Pest Concerns during Backlog Reforestation

by
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WHY CONSIDER PESTS AT ALL?

First, taking a holistic approach, pest species are only pests depending on how they are defined. Ecologically, they may not always be pests. Pest organisms are a natural part of the forest ecosystem and serve as nutrient cyclers and modifiers of soil texture and moisture. They also assist in reaching or maintaining a climax forest. Thus, no matter what we do in the forest, the pest species will almost always prevail but will usually only become 'pests' in certain situations. Second, pests, when given the opportunity, can cause significant damage, even to the point of creating more backlog. Third, as the level of management increases (i.e., silviculture surveys, site preparation, nurseries, planting, research, brushing and weeding, etc.), the investment in the trees increases, as does the value of losses to pests. An initial investment in pest management may create significant savings in the future. Finally, forest managers should anticipate the possibility of a catastrophic introduction of an exotic pest (e.g., white pine blister rust, dutch elm disease, gypsy moth) and the consequences of monoculture plantations.

WHAT CAN WE DO ABOUT PESTS?

Although we cannot "look to the past" more than thirty years in the North, it appears that pests can significantly limit site productivity. Fortunately, backlog reforestation offers an opportunity to reduce these losses, especially at two stages, and reinforces the old saying that prevention is cheaper than the cure. The first stage is during reforestation planning and site preparation when the level of infection by root rots may be reduced or eliminated. Rehabilitating a site that had a component of Sx without treatment of probable root rot and replanting with spruce could result in an NSR plantation twenty-five years later, depending on the infection level. Uprooting stumps and raking *Phellinus*, *Armillaria* and *Tomentosus* infection centres are presently being evaluated as means of ridding forest land of root disease, in some cases permanently. Fortunately, not all backlog sites are a concern for root rots. Sites containing pure aspen, for example, will not require treatment for *Tomentosus* root rot since a rotation of deciduous has allowed the rot to die out. Thus, by appropriate planning, surveying and implementation of mechanical site preparation, long-term net benefits may be attained.

The second phase of the rehabilitation process useful for reducing pest losses is the seedling production and planting phase. Present stocking standards should be applauded since they have attempted to account for, among other things, the risk of mortality due to pests and other causes by distinguishing target and minimum stocking levels.

In tune with this symposium's theme, we can 'learn from the past, look to the future' by developing and implementing various techniques at planting to minimize losses based on prior knowledge. For example, we can delay planting in high-risk or high-hazard areas to avoid cutworm or vole damage, or plant non-host (i.e., alternate) species on known root rot centres, or choose different, less palatable stock types when planting during a vole outbreak. In cases where nearby older plantations have suffered severe pest damage, we can learn by our mistakes and prescribe measures to minimize losses. Some areas planted in the early 1970s with monocultures of Sitka spruce in Vancouver and Prince Rupert Regions produced disastrous results and are now designated as having a high hazard of spruce leader weevil damage. Species selection guidelines in these areas now recommend planting lower percentages of spruce and favour natural regeneration of other acceptable species. Recently, an outbreak of Douglas-fir leader dieback caused some concern about its potential for creating more backlog. It was studied and found to be common to Douglas-fir planted in frost pockets where frost damage was attacked by *Schlerophoma* and other diseases. By planting an alternate species in frost pockets, the problem can be avoided.

In conclusion, I would like to reinforce some fundamental ideas. Survey data are important from both a silviculture and pest-management perspective. These surveys should tell you what you have (both trees and pests) or what you might have in the future. From them you should be able to make prescriptions that include pest concerns and establish priorities for treatments that at least will not exacerbate pest damage. In looking to the future, we should decide what we want in the next rotation and plan accordingly (i.e., specific prescriptions for site preparation and planting, etc.). Outside the scope of pure backlog, we should also be monitoring plantations past free-growing. The impacts of many pests are not apparent until the stand is twenty to thirty years old, a period which we are presently underutilizing from a pest-management perspective. Thus, the message I would like to leave with you is to "Think Pests" and remember that prevention is cheaper than the cure.

Silviculture in British Columbia: The Future

by
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In British Columbia there are five components critical to forestry success.

The first is **opportunity**. Favourable climate, good soils and proven native forest species combine to provide exceptional biological potential. The challenge is to ensure that this potential is harnessed, managed and realized.

The second component required is a **motivating force** behind forestry decisions and actions. Citizens of B.C. are increasingly concerned that forests be renewed because they believe that our forests must be protected. Recent legislative changes to the *Forest Act* have affirmed these demands, ensuring the renewal of forest lands in B.C. as well as the rehabilitation of lands that were previously not properly managed.

The third component needed for B.C. forests is **cooperation** between government, research institutions, the forest industry and the public. Proper forest management requires comprehensive involvement of all interests.

The fourth component is **experimentation**. Better information is needed and more effective solutions must be found. Greater awareness of these needs is creating a favourable climate for experimentation and for prompt adoption of research results.

The fifth component is a **skilled labour force** together with a **pool of expertise in forestry operations**.

How do these five components stack up for the future of forestry in British Columbia?

We all recognize the tremendous forestry **opportunity** that we have in B.C., but we have a great deal to do to harness it. Our ecological program, seed programs and site preparation all have yet to realize their full potential.

The foundations of the ecological program have been laid, so that foresters can use this information to make excellent silviculture prescriptions. Unfortunately, on many forest sites poor silviculture prescriptions are still being applied, and poor priority choices are being made between sites. This indicates either a lack of training or a lack of qualified personnel at the field level.

We have made great progress in B.C. regarding seed, and we must ensure that opportunities for tree improvement and seed orchard programs are fully harnessed, with future direction aimed at tissue and cutting culture, somatic embryogenesis, potted seed orchards and better site preparation.

There is now a tremendous variety of site preparation techniques available for harnessing potential productivity. In the future, crucial decisions will be the matching of site preparation methods to site requirements from both ecological and yield perspectives.

In some sectors there has been a loss of motivating force or faith in forestry for B.C., due in part to rapid changes in forest policy. In the next few years, support and faith for forestry in B.C. must be consolidated and must grow.

Cooperation between various groups has benefitted B.C. forestry. There has been some slackening of this cooperation with the advent of recent policy changes. Our well-planned and sound programs in the past have been the result of good peer review and a requirement for full discussion which has prevented groups from taking divergent paths. I urge that we all keep working in this direction.

We shall continue to see significant changes in silviculture operations. The trend to contracting silviculture activities will continue. We shall see longer-term silviculture contracts and an increase in end-result contracts.

Contractors will have a better understanding of the site dynamics in local areas and will have the opportunity to follow the result of their silviculture operations. The biggest barrier to implementing these concepts is the reluctance of both company and Forest Service personnel to accept some perceived loss of independence.

Simply put, the continued cooperation of various organizations within B.C. will be a critical component for the success of forestry in British Columbia.

Forest **experimentation** in B.C. has increased significantly in recent years, and it must continue to improve. Nationally, forestry research and development expenditures as a percentage of forest product sales are less than half that in the U.S. and Scandinavia. With increased silviculture investment and the continuing importance of forestry to Canada, it is mandatory that research efforts be increased.

Areas of high priority for R&D for forestry in B.C. are: species and stock trials; fertilizing at time of planting; vegetation management; mechanized planting development; growth and yield; wood quality; intensive forestry; economic cost-benefit analysis for silviculture operations; and studies conducted by Forintek.

The Forest Resource Development Agreement has been a strong force in providing the opportunity for greater silviculture experimentation in B.C. Every individual in the forest industry and the Forest Service has benefitted from this agreement, as has the public.

All of us must act to ensure that this agreement is renewed and enlarged by making MP's, MLA's, other government officials and the public fully cognizant of the benefits this agreement brings to B.C.

To **skilled forestry personnel**, forestry offers opportunities for experimentation, for incorporating new businesses, for applying new computer techniques to forestry operations, for developing new machinery, and for improving work techniques in silviculture operations.

The greatest future human resource challenge is training. To cope with the increasing rate of technological change and to ensure that new research results are implemented into operations, our industry must dedicate more work time to continuing education, at all levels of an organization.

In B.C., the Silviculture Institute of British Columbia provides excellent advanced forestry training. We must ensure that our human resource is constantly trained and educated if our nation is to survive and prosper in the competitive forestry field.

Our challenge for the future is to continue to have faith in an industry with many uncertainties: in which decisions must be made about new forests without knowing what products will be manufactured from the final harvest, or into which of the world's markets they will be sold, or at what price. We must continue to expand, strengthen and discover new ways to build on our history of cooperation in the industry. Our forests of tomorrow will depend on experimentation to assure dynamic progress in practices and products.

Our forests of tomorrow will be judged by different and probably higher standards to meet future needs and expectations. To manage and develop our future forests, we shall require a human resource with a high level of expertise, gained through continuing education.

Our future success will depend on long-term, joint commitment by our communities, forest landowners, forest industry and governments to establish and perpetuate new forests. Foresters will be challenged to provide the communication and new technical skills to make this possible.

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